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GOVERNMENT EXPENDITURE ON SCIENTIFIC AND INDUSTRIAL RESEARCH

IN its third report for the session 1948–49, the Committee of Public Accounts refers again to the question of the statutory authority for continuing services which involve substantial expenditure by Government departments. The Committee of 1947–48 in its second report had suggested, *inter alia*, that the expenditure on the Vote for the Department of Scientific and Industrial Research should be covered by statutory authority other than the annual Appropriation Act. In evidence before this year's Committee, the Treasury stated that the first convenient opportunity would be taken to embody the functions of the Department of Scientific and Industrial Research in a statute, and this promise of legislation is welcomed by the Committee in its third report.

It will be recalled that the expenditure of the Department was closely scrutinized by the Select Committee on Estimates in the course of a careful review of the nation's expenditure on research and development, which was the subject of the third report of that Committee for the session 1946–47. The Select Committee had before it a long memorandum from the Department, dated January 1947, on its domestic and inter-departmental responsibilities, in which the full post-war expenditure is estimated at £4,035,000. In the minutes of evidence appended to that report, the Select Committee asked that the estimates should be broken down into further sub-heads indicating more precisely how the vote is to be spent and distinguishing, where possible, the larger capital expenditures on plant and instruments. Neither the Committee of Public Accounts nor the Select Committee on Estimates anywhere suggests that these considerable sums of money involved are not wisely spent or that the Department of Scientific and Industrial Research was reluctant to provide the information desired. The soundness of the contention that more detailed information should be supplied is, however, corroborated by the report for the year 1947–48, which has recently been issued by the Department (see p. 643). Although gross expenditure of the Department for the year was only £3,062,172 in place of the £3,449,375 estimated before the Select Committee in January 1947, it is clear that such sums of money justify a much closer scrutiny by Parliament, even if, as the Select Committee recognized, special methods of accountability may have to be introduced to ensure a reasonable degree of flexibility and freedom in the conduct of research. Moreover, as the Advisory Council itself points out in the report just published, during the present shortage of scientific man-power as well as of buildings and equipment, the claims of the Department on the nation's resources will often be in conflict with those of industry and of the universities, as well as of other Departments of State.

Quite apart, therefore, from the additional reason for close scrutiny of expenditure provided by the

present financial stringency, the right distribution of our scientific resources of man-power and materials, both within and without the Department of Scientific and Industrial Research, is a matter of the utmost importance. It is equally important to strike the right balance between short-range and long-range work, and in regarding this as its major problem of policy, the Advisory Council of the Department should be able to count on the support of the Advisory Council on Scientific Policy and of the scientific and industrial world at large. In its current report, the Advisory Council for Scientific and Industrial Research is concerned almost exclusively with questions of policy, and more particularly those that have determined the post-war development of its activities. Broadly speaking, it may be said that the review justifies the claim that the Council has struck a reasonable balance between the need for giving assistance on problems of immediate and pressing importance, and the need for providing the basis for those more far-reaching advances in industrial technique and practice on which the continued prosperity of Great Britain ultimately depends.

From that point of view, it is appropriate that practically the whole of the present report should be devoted to the discussion of matters of policy. Nevertheless, the omission of all reference to current work and of any summary of the work of the Department's research stations or boards, or of the research associations, is to be regretted for a reason given by the Select Committee on Estimates in complimenting the Department on its pre-war annual reports. The need for regular, balanced and sober statements of the Government's research activities, so far as possible in a non-technical and readable form, is greater and not less than ten years ago. The omission of such accounts might have been overlooked in a broad review of ten years work, particularly if references to the reports of the individual research boards or stations and to other publications of the Department during the period had been included in accordance with pre-war practice. As it is, without these, and without the sub-heads of current expenditure requested by the Select Committee on Estimates, it is difficult to form an independent opinion of the soundness of particular proposals, even those which, like the programme for mechanical engineering research and hydraulics research, have the strongest *a priori* claims, or of the balance of the whole with other national research needs.

An important feature of the Advisory Council's report is that in which the position of the research associations is reviewed, and the policy pursued in that field is outlined. The Advisory Council emphasizes the striking contribution which the research associations made to the war effort, although in 1939 there were still only twenty-two grant-aided research associations, with a total annual expenditure of £480,000, of which £170,000 was provided by the Department. During the decade 1938–48, eighteen new research associations were formed and five were reconstituted; and the grant from the Department in 1947–48 totalled £953,387, and funds raised by industry brought their total income to £2,400,000.

Early in 1943 the Industrial Grants Committee of the Department, then under the chairmanship of Sir Felix Pole, considered the whole future of the research association scheme. While it was regarded as fundamentally sound, the Committee suggested that the relation between Government and industry within the scheme required consideration. It was believed that in the national interest the principle of contemplating a time when each association would become entirely self-supporting, without financial assistance from Government, should be abandoned. It stressed the Government's responsibility for ensuring that there is a well-balanced scheme for fundamental research on which industrial activities can be based, and the national importance of each industry itself possessing a research centre with the task of stimulating the application of science. The Committee also emphasized the value of the contacts between the research associations and the Department, although the success of the research department movement was attributed largely to the preservation of their autonomy. The Advisory Council has fully endorsed a scheme formulated by the Industrial Grants Committee for establishing a panel of visitors to the research associations, chosen from prominent men of science and industrialists. Nevertheless, while satisfied that grants to research associations should become a permanent part of the Department's policy, and recommending the continuation of the existing system of block grants and additional grants for five-yearly periods, at any rate for research associations in the earlier stages of development, the Industrial Grants Committee does not lose sight of the vital importance of adequate support from the industries concerned. When a research association attains a larger scale of operation, the Committee considers it should receive only the block grant necessary to secure adequate prosecution of long-range researches; but it does not suggest that all industries should be treated alike.

In accordance with this view, the Advisory Council of the Department proposes to leave the Industrial Grants Committee free to deal with each industry in the light of its circumstances and needs. Moreover, recognition of Government responsibility for stimulating industrial research does not lead the Advisory Council to propose that an industry should fail to shoulder its just share of the financial burden. On the contrary, the Council is not prepared to encourage the formation of any new research association unless the industry concerned is prepared to support it, from the start, on an adequate basis. Further, if an industry refuses to finance its research association on a sufficient scale, it is proposed that its grant should cease.

These observations show that the Advisory Council is drawing sound conclusions from the experience of the past twenty-five years. Those research associations which have prospered and received sufficient support from their industries to provide them with a sense of security and confidence have been able, as the report emphasizes, to consider their functions in a wide and imaginative way; and what this section of the Advisory Council's report says about the primary

functions of the research associations is admirable and indicates ways in which their value could be enhanced. In particular, their contribution to technical education may well be even more important than the brief reference to it in this report indicates.

There are, however, some fundamental reasons for the success or failure of particular research associations, and for their effective co-operation and contact with the industries they serve, which should be considered. There is also the question of alternative means of assisting research for industry. It is quite clear that the Advisory Council has an open mind on this matter, and in particular has given attention to the possibility of meeting the needs of small firms by a system of sponsored research or industrial fellowship on the lines of the Mellon Institute in the United States and similar bodies. It comes closest to the real issue in discussing the bridging of the gulf between the initial development of a new technique and its adoption in practice. Here it rightly points out that for effective progress this intermediate operation must be conducted by men who are familiar with the initial scientific work and who are also well versed in works' practice. It is not sufficient for a research association to produce results and disseminate them merely by the written word to its industry. Unless their implications are understood, the results will not be applied in the works, factories and mills. The crucial question is whether the research associations can provide research staff both familiar with the new technique and with the works' methods.

Moreover, this question of liaison and of interchange of staff between industry and the research associations bears equally on another vital question: Are the research associations capable of selecting the right targets in their long-range research on fundamental scientific principles? The task is not easy, and depends essentially on attracting to the service of the associations men of the requisite scientific ability and also industrial or technical experience. Further, as the Advisory Council recognizes, the conditions of service must be such as to retain the services of scientific leaders of this kind. Without such men the research associations undoubtedly will not attain their full stature; but the question that requires consideration is rather whether, even with them, the research associations are giving a return to the nation commensurate with the expenditure of money, materials and staff involved, or whether more effective results could be obtained in some other way. The Department of Scientific and Industrial Research is undoubtedly considering the functions of the research associations with both imagination and realism, and is alive to the possibilities they offer in the way of training staff for industry as well as for co-operative work on problems which concern two or more industries at once. Nevertheless, the answers to such questions as have been indicated are not given in the present report, nor is there evidence that the weaknesses revealed by the Select Committee on Estimates in its inquiry into expenditure on research and development are being remedied.

Since the Department issued its last annual report in 1939, the general structure of the nation's organisation for scientific and industrial research has grown immensely more complicated. The whole climate of research has changed as well. References in this report to research in the nationalized industries and to the new development councils indicate that the Advisory Council is fully aware of new factors and the changed context in which some of its work is done. The facile assumption that more men and more money automatically mean more effective scientific and industrial research must, however, be guarded against. The value of the Department's system of grants to research workers and students might have received more emphasis, and the implications of the increasing extent to which the Department is now in competition with other Government bodies, the universities and industry for resources should have been stressed.

It is this last factor, even more than the increasing scale of expenditure, which makes it imperative that the fullest possible amount of information should be available for public discussion on the activities of the Department. The next annual report should be free from the obligation to review a decade, and should be able to supply the popular summary of the Department's activities during the year which used to receive wide notice in the Press before the War. It should not be too much to expect that it will also include the greater detail suggested by the Select Committee on Estimates, and also the material for a sound judgment on some of the questions raised above, if, indeed, it does not reveal that action has already been taken to deal with some of the weaknesses to which the Select Committee on Estimates directed attention two years ago.

ELECTRICITY SUPPLY ENGINEERING

Étude électromagnétique générale des machines électriques

Par Prof. R. Langlois-Berthelot. Pp. 284. (Paris: Éditions Eyrolles, 1949.) 1,600 francs.

Étude industrielle générale des machines électromagnétiques

Par Prof. R. Langlois-Berthelot. Pp. 300. (Paris: Éditions Eyrolles, 1949.) 1,700 francs.

IT is at first sight surprising that anyone should write a treatise on power-frequency electrical engineering, since comparatively little of a novel nature has been added to either theory or practice of electrical machines in the past twenty years. Within the last few years, however, the electricity supply systems of many countries have been integrated into a well-defined unit in which all the generating stations operate in conjunction with one another on a large, common high-voltage network. This practice has resulted in the development of much larger generators, transformers and other equipment than were used when individual power authorities operated comparatively small local electrical systems. Many problems involving stability of operation, short-circuit stresses, surge voltages and load control have thereby become accentuated. Great numbers of people have also become intimately interested in large-scale electricity supply; in Great

Britain, for example, the British electricity supply industry employs about 150,000 people, most of whom should aspire to attain a good level of technical knowledge regarding the equipment used in providing the public with electrical energy.

France was some years ahead of Great Britain in nationalizing electricity supply, and has an electrical system of comparable size, and with many common technical features. The work under review gives a general account of French electrical engineering practice.

The author's method of dealing with his subject is novel. He uses the method of successive approximations in a way which gives the reader a good general idea of the subject from a very early stage. He enlivens the early descriptions with brief historical notes on pioneer inventors and inventions.

The theoretical treatment is simple, the author indicating that he considers mathematicians to be of secondary importance in electrical engineering developments, which must remain largely matters of judgment rather than of calculation. It is difficult to contest the author's attitude to mathematics in face of the personal characteristics of most of the leading personalities who pioneered the development of electrical machines. Aspiring youth should, however, remember that there would have been no quantitative basis of design but for mathematicians such as Clerk Maxwell, Kelvin, Heaviside, Heyland and Fortescue. In the specific case of the high-voltage power transformer, mathematical analysis was far ahead of practice at one time, and the mathematicians failed only because they had not the courage of their convictions, so that winding insulation practice was not made rational until experimental physicists provided proof of the correctness of mathematical analysis by practical tests.

The author does everything possible to ensure that the understanding rather than the memory of the reader will be exercised.

The first volume, "A General Electromagnetic Study of Electrical Machines", describes the characteristics of such machines and arranges them into categories with common characteristics. It then gives an outline of the theory and constitution of transformers and rectifiers, and rotating machines. It concludes with notes on the operation of machines, constant voltage – constant frequency systems, impedances, and polyphase systems.

The second volume, "A General Industrial Study of Electromagnetic Machines", provides an introduction to machine technology from the points of view of the constructor and of the user. It provides reliable general information on materials of construction, principles of design and theory of operation such as will suffice for the constructors and operators of electrical plant.

Each volume is self-contained, but forms part of a four-volume treatise designed for students and electrical engineers other than specialists.

The author has intimate knowledge of his subject, and is an enthusiast who has taken immense pains to explain almost every detail. The reviewer's main criticism is that the author sometimes explains too much and too often. On the whole, however, interest is maintained at a good level, and the books provide an excellent and comprehensive survey of the aspects of electrical engineering which are likely to be of greatest value to those who are, or will be, engaged in the electricity supply industry as now constituted.

C. W. MARSHALL

EX HIBERNIA LUX

The Life of George Berkeley, Bishop of Cloyne
By Dr. A. A. Luce. (Bibliotheca Britannica Philosophica.) Pp. xi+260+13 plates. (London and Edinburgh: Thomas Nelson and Sons, Ltd., 1949.) 25*s.* net.

A CRITIC of this biography has doubted whether the life of a philosopher could be worth such a solid volume. He must have been thinking in terms of the model nineteenth-century philosopher, who oscillated between study and lecture room and produced a complete system of the universe in ten volumes or a commentary on somebody else's system in even more volumes. Eighteenth-century philosophers and philosophy were not built to this model. Berkeley in his own view was first a Churchman, second an Irishman and third a philosopher. His important philosophical writings were designed to combat certain fashionable doctrines which he saw to be causes of infidelity and immorality. Posterity may regret that Berkeley's philosophy is not more constructive; but sensible men do not worry about posterity, finding their own age enough to cope with. The most important of his other writings are those of a patriotic Irishman urging his countrymen (Catholic as well as Protestant) to make the best of the Hanoverian settlement, and endeavouring to improve their economic condition. The very pertinent questions posed by Berkeley in "The Querist" undoubtedly stimulated Hume and Adam Smith and contributed to founding economic theory. In addition, he made his house and glebe at Cloyne (with the valuable help of Mrs. Berkeley) an example of good husbandry and industrial enterprise for the benefit of the whole countryside.

Prof. A. A. Luce makes quite clear the source of the legend that Berkeley was a dreamy visionary with his head in the clouds and how baseless that legend is. On the contrary, Berkeley was a man with his feet planted firmly on the ground, physically vigorous, mentally alert, interested in everything, and had he lived a few centuries earlier we should now be referring to him as St. George (of Ireland).

However, there are puzzling things about Berkeley's career which Prof. Luce helps to clear up, especially about his project for a university and missionary college in Bermuda. It is easy to see after the event that Berkeley would have been wise to cross to America before launching his scheme. He was misinformed about conditions over there; but so were the King's ministers and others whose business it was not to be misinformed. Curiously enough, one of Berkeley's supporters was a native of Massachusetts and a graduate of Harvard. Prof. Luce thinks that Walpole was much to blame for the public money not being made available and for no modification of the original scheme being tried, but so also were certain influential persons who held that too much education would make Americans too independent. Berkeley's project failed, but his stay in America was far from being fruitless. His influence on American education was substantial and is well remembered on that side of the Atlantic.

Berkeley's advocacy of the medicinal use of tar-water is more likely to be misunderstood nowadays. But tar-water (from wood tar, of course) is easily and cheaply made by anybody; it is a mild antiseptic suitable for internal or external use. In those days, when medical men were few and their knowledge

small, it would help to combat many infections, and would do much less harm than most of the official remedies of the profession. Indeed, the only contemporary complaints seem to have come from a few disgruntled medical men who disapproved of blacklegs. If Berkeley himself rated its virtues too high, it was because of the enthusiasm of grateful patients. There are two minor mysteries which Prof. Luce has not been able to clear up. How is it that no correspondence between Swift and Berkeley has come to light? And what were the circumstances that led the unhappy 'Vanessa' to make Berkeley her heir?

It is nearly two hundred years since Berkeley's death, and this is the first full-length biography to appear. The wait has perhaps been worth while. Nobody in earlier times was so well equipped for the task as Prof. Luce. Other lives may possibly be written; this one will be read. A. D. RITCHIE

ENERGY AND MATTER

Energy and Matter

By R. L. Worrall. Pp. 144. (London: Staples Press, Ltd., 1948.) 10*s.* 6*d.* net.

THIS unusual book opens with a quotation from Lenin—"Modern physics is in a state of confinement; it is giving birth to dialectic materialism". The author is a medical man whose previous book, "The Outlook of Science", was first published in 1933 and reached a second edition in 1946. The greater part of the present book is a history of the evolution of ideas concerning matter and energy. It is emphasized that Newtonian ideas, in which mass or inertia was the characteristic property of what is usually called matter, must now, in the light of Einstein's work, be modified so that what is usually called energy must also be attributed with mass. Every physicist will agree with this, and will be interested in the quotations from Newton, Maxwell, Einstein, and others. Dr. R. L. Worrall's distinctive contribution is to insist that the term matter should now be extended to include what is usually called energy. When a distinction is needed, we can speak of the corporeal and incorporeal state (p. 62).

Probably most physicists would consider the issue raised an entirely verbal one, adding nothing to the accumulated facts of the science or to the mathematical theories co-ordinating those facts. However, Dr. Worrall would not agree. On pp. 61–62 he says: "If the material character of radiant energy was recognized, it would not be possible to regard matter as absolutely inert. Matter would then be seen to have an active as well as a passive quality; motivity as well as inertia. Instead of the current view that inert matter is acted upon by non-material energy, matter would be recognized as self-motivated. All this would conflict with theology, which teaches that something supernatural is ultimately responsible for the activity of 'inert' matter. Physics, therefore, retains the assumption that matter is absolutely inert, and that radiant energy is non-material in character. Modern materialism has no such attachment to theologically inspired assumptions. Defining matter as that which exists independently of thought, we can see that matter is active as well as passive, self-motivated as well as inert."

In the opinion of the reviewer, theories concerning physics should be based entirely on the experimental evidence available and the mathematical co-ordination of this evidence. Whether these theories agree or not with theology or dialectic materialism is entirely irrelevant. Most of us think it was monstrous that Galileo's astronomical theories were condemned by the Holy Office. However, this was more than three hundred years ago, and is now obsolete; but it is alarming that Prof. E. A. Milne's astronomical theories are condemned by Dr. Worrall (p. 113) on the ground that "Milne's kinematical time-scale involves a theological assumption, namely, a beginning of time at a supposed creation of the universe". Let us hope that there will never arise a new Unholy Office, with power to force recantation of scientific theories which are considered likely to support theology. H. T. H. PIAGGIO

NEW STAR CHARTS

Skalnate Pleso Atlas of the Heavens 1950·0

By A. Becvar. Pp. ii+16 charts (18 in. × 25 in.). (Cambridge, Mass.: Sky Publishing Corporation, 1949.) 5 dollars.

Mappa Coelestis Nova

Containing all Stars brighter than 5·0 Visual Magnitude classified according to the Henry Draper Catalogue. (Cambridge, Mass.: Sky Publishing Corporation, 1949.) 3.50 dollars.

THE Skalnate Pleso Atlas of the Heavens is named after the new astrophysical observatory at Skalnate Pleso (Rocky Lake) in the High Tatra Mountains of Czechoslovakia, the director of which, Dr. Antonin Becvar, planned the work and, with the aid of a devoted and enthusiastic band of collaborators, carried it through in less than a year. The Atlas was published in Prague in 1948, but shortage of paper limited the number of copies that could be printed. The present edition, published in the United States from duplicate negatives, will make the Atlas available to all who require it.

Every observatory and every amateur observer should possess this Atlas. Its sixteen charts show the positions of all the stars (32,571 in number) down to 7·75 visual apparent magnitude in the whole sky, depicted in a graduated scale of images with sixteen steps. Double and multiple visual and spectroscopic systems are shown in a manner which indicates the number of visual and spectroscopic components. Novæ and variable stars with maximum brightness 7·75 or brighter are shown. The positions and relative dimensions of galactic star clusters, globular clusters, planetary nebulæ, extragalactic nebulæ of magnitude 13·0 or brighter, and of the principal galactic gaseous nebulæ are depicted. The principal dark nebulæ and obscuring patches as well as the outlines of the Milky Way are shown. The galactic equator, the ecliptic, and the limits of the constellations as adopted by the International Astronomical Union are marked.

The Atlas will be useful to the professional astronomer in a variety of ways and particularly in planning observational programmes. To observers of double and variable stars and to comet searchers it will be invaluable. The Atlas is well printed on paper of excellent quality and is good value at the published price.

The Mappa Coelestis Nova is also a reproduction of a chart published in Prague. It shows the principal naked-eye stars (to about the fifth magnitude) in the

sky down to declination 40° S., in a single chart. The limits of the constellations are marked, the constellations are outlined, the names and Greek letters of the principal stars are given, and the magnitude of each single star is indicated. Novæ, double stars, nebulæ, clusters, and meteor radiants are shown. But the unique feature of the chart is that the spectral type of each star is indicated, stars of spectral types *B*, *A*, *F*, *G*, *K* and *M* being shown in blue, white, green, yellow, orange and red respectively; the colours have been inserted by hand and not obtained by successive colour printing, which may account for the rather high cost of the chart. For many purposes of quick reference the chart will prove very useful.

H. Spencer Jones

SCIENTIFIC ORCHID GROWING

Orchids are Easy to Grow

By Harry B. Logan and Lloyd C. Cosper. Pp. viii+312+20 plates. (Chicago and New York: Ziff-Davis Publishing Co., 1949.) 6 dollars.

THE chief developments in horticulture in Great Britain during the past forty years have been the increasing popularity of hardy shrubs and herbaceous plants for growing in the open, and the steady application of scientific knowledge to the cultivation of all kinds of plants. The former tendency, due to the introduction of numerous high-altitude Chinese plants, on one hand, and the redistribution of wealth, on the other, has struck a heavy blow at the cultivation of greenhouse and stove plants, of which orchids have always been the most popular. The number of amateurs interested in orchids has greatly diminished, and this, coupled with a disposition to regard orchid growing as a kind of mysterious cult, has retarded to a great degree the application of scientific methods to this branch of horticulture.

In "Orchids are Easy to Grow", the authors propound in a convincing manner the view that the proper application of scientific outlook and method to the growing of orchids can bring them within the reach of any seriously minded gardener who is prepared to take a little trouble. Although written primarily for the American public, most of the subject-matter is equally applicable to orchid growing in other temperate regions.

After introductory chapters describing the nature of orchids and the fundamental rules of orchid culture, chapters follow on growing orchids in the home, in the garden, and in greenhouses of various types. Other chapters deal with the details of cultivation, treated in a very practical manner, while there is a series of chapters on the more important orchid genera in cultivation. Throughout the book emphasis is laid on the scientific aspect of the subject and the necessity of applying knowledge in a logical manner at every step. It is unfortunate, therefore, that in a number of places the botanical information is not accurate, while the nomenclature and terminology is at times rather hazy. For example, the terms 'genus' and 'family' are used interchangeably in some instances. The checking of the manuscript by a competent botanist would have prevented these blemishes in an otherwise useful and interesting book.

Apart from numerous illustrations in the text, there are a score of beautifully reproduced coloured plates, mostly of artificial hybrids.

V. S. Summerhayes

NATURAL HISTORY OF THE INTERTIDAL ZONE

The Sea Shore

By Dr. C. M. Yonge. (New Naturalist Series.) Pp. xvi+311+72 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1949.) 21*s.* net.

THE scholarship of years and the spirit of youth, together with grace and charm of exposition, combine to make Prof. C. M. Yonge's book on the life of the sea shore a pleasure to read. This is another volume in the eminently successful New Naturalist series, which is designed to present British natural history in modern scientific perspective for the general reader. It is quite obvious, however, that more than the general reader is catered for, and the biologist, as well as men of science in other fields, will derive profit and enjoyment from this synthesis of knowledge concerning the British intertidal fauna and flora.

Although the sea-shore includes a relatively small area of the British Isles—somewhat more than 600,000 acres—it represents a region that is very richly populated by marine plants and animals, and includes many diverse types of invertebrate animals that are easily accessible to study nowhere else. It is a valuable training ground for the young zoologist, and the multiplicity of diverse environmental factors operating in this narrow zone makes the study of functional adaptation one of peculiar interest and complexity.

The background of this book is threefold: the animals and plants of the shore; the character of the substratum; and the nature of the sea-water medium laving it. These large fields have been succinctly but carefully presented. Against this backdrop is presented a drama of intertidal life, as seen in rock pools, on and under rocks and seaweeds, on sandy shores, muddy shores, and in estuaries. Special groups and environments are treated separately, as shore fishes, barnacles and molluscs, rock and wood borers, and fouling organisms. In addition to describing peculiar adaptations of individual species to their particular niches, analyses of general delimiting factors are presented. This is particularly well shown in zonation on rocky shores, where each species is restricted to an optimal level determined by physical and chemical conditions of light density, exposure or immersion, temperature, salinity, and by gravity responses. Horizontal as well as vertical distribution is affected by external factors. Temperature plays a part in restricting species to lengths of the coast-line; other influences, still unknown but possibly ascribable to minute and undetected differences in composition of Atlantic water, are still to be found.

A pleasing feature of this book, in common with others of this series, is the account of the history of shore biology in Great Britain. This can profitably be read in conjunction with "British Marine Life" by the same author. Salient works are referred to in the text, and there is a useful bibliography in an appendix. The illustrations are outstanding and comprise, besides text-figures, excellent photographs of living animals in their natural surroundings. The majority are by Dr. D. P. Wilson, well known for his photographs of marine organisms, who has produced a special series of coloured, as well as black-and-white, photographs for this volume. In general, the colours are good. The text is remarkably free from errors.

J. A. Colin Nicol

FORMATION OF THE STARS AND DEVELOPMENT OF THE UNIVERSE

By Prof. PASCUAL JORDAN
Hamburg

Introduction

IN a fascinating article which appeared in *Nature* of February 6, under the title "Stellar Evolution and the Expanding Universe", Mr. F. Hoyle has brought forward convincing arguments for the permanent creation of matter in space. Many physicists will find it difficult to accept this hypothesis. For if there is any law which has withstood all changes and revolutions in physics, it is the law of conservation of energy, which according to Einstein's formula $E = mc^2$ is equivalent to the conservation of mass. The same strange conclusion has, during recent years, been formulated by Prof. Pascual Jordan, but with an important modification, whereby the conservation law is not violated. This is achieved by taking account of the loss of gravitational energy connected with the creation of particles. As Jordan's papers do not seem to be known to many English-speaking physicists, I have asked him to write a short report of his work, and the following article is a translation of his article made by my collaborator, Dr. H. S. Green.

Max Born

Since the formulation by Einstein of the general theory of relativity, many theoretical considerations have been advanced in which models of the universe are derived *deductively* from certain physical principles (expressed in the form of field equations), which are adopted as hypotheses. The treatment here explained is an attempt to approach the problem more cautiously. It is necessary to reckon with the possibility that processes and natural laws are involved which lie outside our past experience, and which must be learnt by the examination of the universe: an essentially *inductive* approach to the cosmological problem must be sought. The dimensional analysis of the empirical facts presents itself as the method appropriate to this task. This method proceeds by the combination of the experimental data to form dimensionless quantities, and the comparison of these dimensionless numbers with regard to their order of magnitude.

Dimensionless constants, the significance of which remains to be explained, are, as is well known, already apparent in atomic physics. Many attempts have been made to elucidate the significance of Sommerfeld's fine-structure constant and the ratio of the masses of the proton and electron. Though Eddington's well-known considerations have not led to the solution of these problems, he has very usefully made apparent their great urgency and importance. The discovery of different kinds of mesons has intensified these problems: a theory which could explain the mass ratios of the different kinds of mesons could probably account also for the two constants already mentioned. The reciprocity theory of Born and Green promises some interesting progress in this direction.

There is, however, an even more significant dimensionless constant in microphysics. If the ratio of the electrostatic and gravitational attractions of an electron and a proton is formed, the number 2×10^{39} results.

Can it reasonably be hoped that this value can ever be established by theoretical considerations? Eddington cherished the optimistic view that it could; but his speculations really only served to make one more acutely conscious of how improbable it is, on the basis of such natural laws as are known, that an explanation could be given of why a dimensionless constant should have just this enormous value, and not some other. It is not so much a question of the particular natural laws known to us to-day, as of the *mathematical type* common to all the known laws of physics. The mathematical type which characterizes physical laws allows the explanation of such natural constants as π, or 4π, or $\sqrt{2}$; but a number of the order of magnitude 10^{40} can never arise from the mathematically simple, fundamental laws of Nature. But should it now be believed that there are, in the laws of Nature, numerical constants which by a meaningless chance have their actual values—which could equally well assume other arbitrary values, without producing a fundamental discord in the harmony of the natural laws? It is an outstanding merit of Eddington that he emphasized that we should never believe in meaningless coincidences.

There are six distinct quantities which comprise the sum of our knowledge of the structure of the universe on a large scale. After the velocity of light, c, and the gravitational constant, $k = 8\pi f/c^2$, where f is the Newtonian gravitational constant, comes thirdly the maximum age of the oldest celestial bodies known to us. From a variety of data and considerations, one arrives at the conclusion that none of all the known stars and systems of stars can have existed for longer than a certain maximum time, which is approximately 4×10^9 years. Thus one has a quantity of the order of magnitude $A = 10^{17}$ sec.

Three constants additional to those already mentioned are furnished by the statistics of the spiral nebulæ. From the enumeration of the nebulæ, and the determination of the masses of a cross-section of typical nebulæ, one obtains the value of the mean mass-density μ throughout the universe; this comes to about 10^{-28} gm. cm.$^{-3}$. The second of the three 'constants of the spiral nebulæ' is the constant α of the Hubble effect. The spectral lines of the very distant nebulæ show a displacement to the red, which may be described simply by the empirical fact that if a spectral line has the wave-length λ, then the displacement $\Delta\lambda$ is proportional to λ, and also to the distance r of the nebula from us, so that one obtains always the same value for $\alpha = c\Delta\lambda/\lambda r$. The third constant of the spiral nebulæ is empirically the worst determined. It seems, however, that the number of those spiral nebulæ the separation of which from us is in the interval $r, r + \Delta r$, is rather less than proportional to $4\pi r^2\Delta r$, that is, approximately proportional to $4\pi r^2(1 - \text{const.}\, r^2)\Delta r$. Here the constant defines the radius of the universe R, to the square of which it is inversely proportional.

The assembly of cosmological data is now complete; and it may be inquired what dimensionless constants can be constructed from c, k, A, μ, α and R. Such are αA; R/cA; $k\mu c^2A^2$; and it is an

extraordinary thing that all three are of the order 1. This is the justification for an attempt to interpret these constants by means of the following simple and illuminating picture. The 'radius of curvature' R is interpreted—and is for that reason given such a name—in the sense of Riemannian geometry: instead of the infinite Euclidean space, one has thus a closed, finite, Riemannian space, the volume of which is of the order of magnitude R^3. In the same intuitive way the Hubble effect is interpreted as a Doppler effect. Different interpretations of the Hubble effect have, indeed, often been attempted, but here the intuitive concept of an expanding space is retained without modification. The empirical relation $R = cA$ then means that the radius of the universe increases at a rate which is just of the magnitude of the velocity of light—an attractive and revealing result. Also $\alpha A = 1$ means that this space, which has been expanding with the velocity of light ever since that time which we recognize to be most remote in the history of the universe, must once have been very small.

But what is meant by the fact that the last of the three dimensionless constants mentioned is of the order of magnitude unity? This relation appears already in the well-known model of the universe which was Einstein's bold attempt, in framing the general theory of relativity, to realize the idea of a closed, Riemannian, physical space. Indeed, if M is understood to be the total mass of the universe—which is then of the order of magnitude μR^3—and cA is replaced as previously by R, the equation in question can be written in the form $kM \simeq R$; and Einstein had previously obtained the relation $kM = 4\pi^2 R$, for a closed space with a *time-independent* radius R, on the basis of the relativistic theory of gravitation.

From a consideration of the Hubble effect, however, the concept of a growing universe has been reached; and then the empirical relation $kM \simeq R$ gives a disturbing conclusion. If R is not fixed, but is always growing, then neither can kM be regarded any longer as invariable; and, of the two factors, the gravitational constant k, and the mass M of the universe, at least one must vary likewise with time. An important contribution to the elucidation of this situation is contained in an observation by A. Haas: the relation $kM \simeq R$ can also be written in the form $fM^2/R \simeq Mc^2$, which means that the negative potential energy of gravitation for the whole universe is equal to the sum of the rest-energies of the masses of the stars. This provides a surprising solution of the problem of the universe: it is possible for the total energy of the universe to have the value zero exactly—through the cancelling out of the positive and negative contributions to the energy. The relation $kM \simeq R$ would then appear as a direct consequence of the conservation of energy, which requires that the evolving universe should continue in a sequence of states the total energy of which always has the value zero.

To proceed further, another dimensionless constant is required; those which can be produced from the six cosmological quantities c, k, A, μ, α and R are exhausted by the three dimensionless constants already mentioned. More are obtained if the cosmological quantities are compared with those derived from microphysics. Hitherto the radius of the universe R and the mass of the universe $M \simeq \mu R^3$ have been expressed in centimetres and grams; now they will be expressed in terms of the fundamental units of microphysics. The choice of these units is, of course, made uncertain by the appearance of the unexplained dimensionless constants of microphysics: it is questionable whether one should take, as the natural unit of mass, the mass of the proton, or that of the meson or electron, and whether the natural unit of length should be Bohr's radius of the hydrogen atom, or the electronic radius $e^2/m_e c^2$, the ratio of which is essentially the square of the fine-structure constant. However, the dimensional ratios with which one has to do are so enormously large that these distinctions are of little consequence; moreover, there is sufficient reason to give preference to the mass m_M of the meson, and to the electronic radius or 'elementary length' $l = 2 \times 10^{-13}$ cm. If the ratio $M : m_M$, which is then of the order of magnitude of the number of elementary particles in the whole universe, is formed, then a number of the colossal magnitude 10^{80} is obtained. Eddington had the boldness to claim that this number should not be simply accepted as something incapable or without need of explanation; he sought, by means of some curious considerations, to give theoretical grounds for supposing that the number of protons in the universe must have the value 2^{256}. The true solution would appear to lie in another direction: an idea which Dirac has put forward in quite a different connexion will now be introduced.

The ratio R/l is of the same order of magnitude, 10^{40}, already encountered in the comparison of the gravitational and electromagnetic attractions between two elementary particles; if these two dimensionless numbers are divided, therefore, a new dimensionless quantity of the gratifying order of magnitude 1 is obtained. The ratio of the two attractive forces is thereby compared, however, with a number which, as is already known, is not constant: the ratio R/l increases proportionally to the age of the universe; it is, in fact, equal to the age of the universe, expressed in terms of the 'elementary time' $\tau = l/c \simeq 10^{-23}$ sec. Also, from the significant discovery of a quotient of the order of magnitude unity, it must be concluded, with Dirac, that the constant of gravitation is in reality not a constant, but inversely proportional to the age A of the universe.

What is now the obstacle to applying this idea also to the ratio M/m_M, and asserting that the number of elementary particles in the universe obviously increases as the square of the age of the universe? Dirac, who was led away from this application by a special train of thought (concerning the formulation of a cosmology with an infinite Euclidean space and an infinite total mass of the universe), was probably influenced by a fear of contradicting the principle of conservation of energy. However, the foregoing consideration has cleared the way in this respect: with the perception that $kM \simeq R$ guarantees the conservation of energy, the complete harmony of all the statements concerning the proportionality of k to A^{-1}, M to A^2, and R to A is attained.

It is, therefore, accepted that there is a continual creation of matter in the space of the universe, and the question arises, how and where this generation of matter, connected with the growth of the universe, occurs. To answer this, the individual stars, instead of the universe as a whole, are now taken as the subject for careful consideration in the light of dimensional analysis. The mass of the sun amounts to 2×10^{33} gm.[1]; there are certainly many stars with still smaller masses, and an established lower

limit scarcely exists. There are, however, on the other hand, few stars with very large masses: 10^{35} gm. = 50 suns may be taken as an approximate value for an upper limit to stellar masses which is very seldom exceeded. It may be asked how many protons such a star would contain: the answer is of the order of magnitude 10^{60}.

Here is a fresh opportunity to apply Dirac's principle, from which it may be concluded that this upper limit, too, must be a function of A; indeed, it must then be interpreted as $A^{2/2}$. According to this hypothesis, the mass of a star (on the average) depends on the age attained by the universe at its formation; this formation being settled, the mass of the star (the number of its nucleons) will remain unchanged (apart from secondary processes, as occasional gathering of dust). Therefore, the normal mass of a star which was generated at an age A_0 of the world must be proportional to $A_0^{2/2}$. (In consequence of this, to-day not only the average mass of recently created stars, but also the average mass of now existing stars has an order of magnitude 10^{60}, proportional to $A^{2/2}$.) Naturally, this dependence of the average of stellar masses on the age of the universe necessarily implies a corresponding dependence of the *gravitational constant*, which is then itself a function of the age of the universe; and, in fact, the proportionality $M_{st} = A_0^{2/2}$, inferred in the first instance from a comparison of the empirical numbers 10^{40} (present age of the world) and 10^{60} (present mass of the normal star), is in agreement with and corroborated by the fact that the present theories of the internal constitution of the stars continually presuppose stellar quantities which are proportional to $k^{-2/2}$.

It has been made clear above that the requirement of conservation of energy on a large scale is satisfied, if a creation of matter is assumed which leads to an increase of M proportional to A^2. Nothing is said there, however, of the way in which this creation of matter can occur. Though the possibility of a localization of energy, like that encountered in Maxwell's theory, can no longer be maintained in Einstein's theory of gravitation, it is certain that in some way a rigorous formulation of the principle of conservation of energy must hold such that, not only for the universe as a whole, but also for a finite region, where the creation takes place, a balance of energy is maintained. Consider now the rough model of a homogeneous sphere with mass M_0 and radius R_0 in an approximately flat, Euclidean space. If it satisfies the relation $kM_0 = R_0$ (apart from a certain numerical factor of the order of magnitude unity) then this space has zero total energy: if it were required to effect a transformation to a cloud of gas of virtually infinite radius, then it would be necessary, in order to overcome the gravitational force between the atoms, to expend just as much energy as would be present in the final state as the sum of the rest-energies. The conjecture suggests itself that the cosmic creation of matter does not take place as a diffuse creation of protons, but by the sudden appearance of whole *drops* of matter, for which M_0 and R_0 are chosen so that each drop, even taken by itself, remains true to the principle of conservation of energy from the instant of its formation—in such a way that the total energy has the value zero.

The critical question at once arises, What density must be ascribed to the drop of newly created matter? It can certainly take only the density of the atomic nucleus, which is of the order of the proton mass, contained in a space of the dimensions of the elementary length. Hence the size of the drop is determined as a function of the gravitational constant at any given time: drops are obtained which contain a number of elementary particles to-day of the order of magnitude 10^{60}, and in general proportional to $k^{-2/2}$ or $A^{2/2}$. Each drop which appears in the space of our universe is therefore a star in its own right.

This picture can be worked out in rather more detail. The universe, regarded as a four-dimensional space-time manifold, is, according to the above, a cone: its apex, $A = 0$, marks the starting-point in time, at which also R and M are zero. It may be imagined, however, that this cone stage does not necessarily possess only one apex, but may have a large number of subsidiary apices. A 'cut' t = const. may then in certain circumstances cut the space-time manifold into several unconnected three-dimensional parts: another isolated, smaller space may exist apart from the large universe, which, by the gradual unfolding of time, and also by its own expansion, may begin to coalesce with the large universe. Supposing that in this small 'world' the mass-density remains constant, and the gravitational constant decreases as the inverse square of its age, then the conservation of energy holds there also. If it is supposed further that when, by such a process, the little world reaches the same value of k as attained in the large universe, it can coalesce with the universe, then it will assume a mass of exactly the same value, at the instant of coalescence, as has been recognized to be characteristic of a newly formed star. Such a world may therefore be regarded as the embryonic state of a star.

A careful discussion of the astrophysical facts seems to indicate that the ideas suggested above are well adapted to give a better understanding of many known empirical facts. Instances will not be developed here; the last two of my papers cited below contain a full discussion. I mention only that I suspect that the supernovæ I (which appear to belong to the star population II, and which, one may venture to say, probably account also for the planetary nebulæ) are stars created in this way.

Finally, it may be noted that the theory, sketched here in a purely inductive manner, has received also a quantitative mathematical treatment. For this, of course, a certain generalization of Einstein's theory of gravitation was required, as this theory treats the constant of gravitation essentially as a genuine constant; and the substitution of a variable k (in Dirac's sense), which must then be treated as a scalar field quantity, requires a fundamental generalization of the theory. For this purpose I found, to all appearances, a very natural starting-point in the five-dimensional (or projective) theory of relativity. The generalization in question has also been studied by Einstein and Bergmann, and by Lichnerowicz and Thiry. In a paper by Ludwig and Mueller, it is shown that, with this new and more general form of the theory of relativity, a deductive foundation and quantitative precision can be given to the model sketched above. This applies to the model of the universe on a large scale as well as to the model of a star in its embryonic state. In this way also the correctness and practicability of the present interpretation of the problem of cosmological energy are confirmed.

After having written this article, I had the opportunity of studying the paper by Mr. F. Hoyle men-

tioned above by Prof. Max Born, and which will be sure to give a new great impetus to cosmological discussion. Several decisive ideas of Hoyle's are in full harmony with my own theory; especially his very convincing arguments against oscillatory models, and concerning the irreversible conversion of hydrogen. But by far the greatest encouragement which I gain from his very interesting discussion is given by his hypothesis of creation of matter. When I put forward in 1939, following Dirac, the idea of an increasing mass M of the universe, I myself believed this to be a rather astonishing hypothesis. Surely this hypothesis will now be discussed earnestly. But there are also considerable differences between Hoyle's theory and my own. The principal point has already been emphasized by Prof. Born. Will Hoyle's thesis (F), namely, the existence of internebular matter, really be accepted by empirical astronomers? I learn from Dr. Baade that he does not believe it.

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FORESTRY AND HILL FARMING

IN the face of present economic difficulties, the right use of the limited area of productive land in Great Britain, shrinking through the demands of housing and industry and through diversion for use by the Services, becomes of prime importance. When the agricultural improver lifts his eyes to the hills in the hope of increasing food production, he finds that the forester has also marked the hills for the development of his forests. The case for increasing home-grown timber supplies is strong and finds expression in an afforestation policy that has been approved in principle by all parties. On the other hand, we must have more home-grown meat, and in this connexion the importance of hill lands is not simply in the actual mutton and lamb produced, but also in their value as a source of the foundation stocks of lowland sheep.

In view of the existence of these conflicting claims on hill land, the holding of a joint discussion by Sections K* (Forestry) and M (Agriculture) of the British Association was opportune, the more so as Newcastle upon Tyne lies on the verge of a great hill area where the issue of sheep versus trees has been actively joined.

In the opening paper, Lord Robinson surveyed the position mainly from the point of view of timber production. He pointed out that hill country forms about thirty per cent of the area of Britain and, except for the highest land, was originally mainly forest. At present it is mainly devoted to grazing. There has been a recession in this type of utilization; apart from the incursions of forestry, the hill areas are less populous, and sheep stocks are lower and less healthy than formerly. The industry supports about one family per 800 acres; the production is about 8 lb. of mutton and 1·9 lb. of wool annually per acre in England and Wales, with lower figures for Scotland. The industry is heavily subsidized, and Lord Robinson doubted if the expenditure on hill farming could be justified unless soil fertility is restored and maintained, and also whether this could be effected except by ploughing and re-seeding.

A conservative estimate of coniferous timber production is 1½ tons of air-dry timber per acre per annum. Employment at first is double that under sheep farming and rises until about one employee is required for 50 acres of forest. The present programme envisages the provision of at least ten thousand new houses and the establishment of new communities.

Lord Robinson held that there is a place both for forestry and grazing in the hills, and both must be planned as economic units. Dollars saved on imported timber can pay several times over for food displaced, but this displacement need not occur if the grazings unoccupied by the new forests are improved.

Prof. R. W. Wheldon, from the agricultural side, emphasized the importance of hill-sheep farming. At present, grassland types of sheep are dominant owing to the decay of arable-sheep farming. Type conservation and the release of lowland areas from rearing require an integration of hill and lowland, and the same applies to a certain degree to cattle. The possibilities of direct food production in hill areas have been enlarged in recent years. In estimating the contribution of the hill areas to our meat supplies, crude estimates of output may be misleading. The hills are important as providing the foundation stocks for lowland meat production. Private estates have successfully combined farming and forestry. The use of hill lands both for sheep and timber is a problem of practical integration.

Mr. A. P. Long dealt with some of the practical aspects of hill forestry in Britain. The ultimate objective of five million acres afforested by the end of fifty years is to be obtained by (1) the maintenance and replanting of existing woodlands, some cleared and some derelict, and (2) the planting of new areas. A proper balance must be maintained between these programmes. In the new plantings some displacement is inevitable; but much of the land is not fully productive, and we cannot afford to maintain land in an unproductive state.

Mr. Long did not consider that the displacement of food would be so great as often imagined. The number of sheep displaced in one year under the present programme is only 0·27 per cent of the total sheep population. The temporary loss could be repaired by a modest increase in production elsewhere. The need for timber is great, particularly for pitwood, which is a major problem in war-time. The general shortage of timber is likely to persist, and we cannot afford to postpone plans for improving our position.

Land for afforestation is acquired in close consultation with the Ministry of Agriculture, and every effort is made to ensure as little disturbance as possible. Planting may occur many years after acquisition, and only rarely is notice given to quit more than part of a farm. Particular attention is paid to the utilization of unplantable land. The main source of forest land is rough pasture, areas that are unproductive being first tackled; for example, bracken land and water catchment areas. Mr. Long also stressed the social implications of the afforestation programme. Employing about ten times as much labour as sheep farming per unit area, it offers a means of checking rural depopulation and building up a vigorous rural community life.

Mr. D. H. Dinsdale dealt with the economic aspects of the problem. Both hill farming and forestry must exist, and the question is, how much of each? The decisive choice must be made not solely on economic, but also on social and other grounds. In the decision, the State, rather than landowners and farmers, will take a decisive role. Since forestry requires the lower and better slopes, the direct conflict cannot always be avoided. Mr. Dinsdale explained the difficulties in trying to determine at what level of effort the marginal net return from farming and forestry would be approximately equal. All large-scale enterprises bear risks, and in his view farming would appear to be safer because it is more flexible. Food shortage appears likely to become more acute against increasing population and, in Britain, a shrinking agricultural acreage. The withdrawal of land that produces food should not be lightly undertaken. Mr. Dinsdale pointed out that the production of meat by the hills by no means measures their contribution to meat supplies. They play a vital part in maintaining our total sheep stocks. Further, the potentialities of hill-sheep farming have been considerably increased by advances in technical skill. With the expansion of arable in the lowlands, more is demanded of the hills.

Although stressing the importance of the hills for meat production, Mr. Dinsdale was hopeful that forestry could be integrated with sheep farming in the hill areas through mutual co-operation.

Prof. G. W. Robinson referred to the 'three story' structure of hill farms, with (1) lowland, (2) 'inby', 'intake', or 'ffridd', and (3) open grazing, representing decreasing intensity of utilization and decreasing natural fertility. Forestry is chiefly interested in the middle story, the total planting of which would make sheep farming impossible by removing most of the winter keep.

Although the economics of sheep farming and forestry need more investigation, economics alone cannot give a solution on account of the insecurity of the fundamental data; for example, future interest rates and relative prices of sheep and timber. Other considerations must be taken into account, notably the present state of sheep farming in a locality and the effect of afforestation on existing patterns of rural society. In some areas the decay of sheep farming may justify the predominance of forestry; elsewhere sheep farming should be the first consideration. In those areas where there is no clear case for the predominance of either, it should be possible to fit forestry to sheep farming on the lines of good estate management. Part of the 'second story' might be taken for forestry, and the remainder might be improved in compensation. This would be possible only if the Forestry Commission is willing to do its planting in smaller blocks. More mutual understanding is necessary. It should be possible to do for the hills what the great eighteenth-century improvers did for the lowlands.

The discussion added little to what was said in the papers. The vigour with which some speakers attacked the Forestry Commission reflected the difference in approach to the problem. While the forester is mainly concerned with executing a Government policy, the sheep farmer is naturally anxious for his livelihood and cannot view it dispassionately as an economic problem. The exchange of views was, however, valuable, and encouraged the hope that in future the problem will be tackled with greater co-operation.

NUTRITION LEVELS FOR LIVESTOCK

As part of its contribution to the central theme of "World Population and World Supplies" outlined by the president, Sir John Russell, to members of the British Association at the Newcastle upon Tyne meeting, Section M (Agriculture) devoted a morning session to consideration of the plane of nutrition of livestock in relation to resources.

The resources now available for the feeding of livestock in Britain are very different from those available before the War, and present the farmer with problems of a complex nature. Up to 1939, with easy access to cheap and abundant supplies of imported feeding-stuffs, the rearing and feeding of livestock, in particular pigs and poultry, presented no difficulty; now, however, the need to conserve foreign exchange, coupled with the pressure to devote a considerable proportion of farm land to the cultivation of food for direct use by man, have not only severely limited the extent to which the farmer can rely on imported feeding-stuffs for the use of his livestock, but has also forced him to look to the farm itself as a main source of his feeding-stuffs.

In these circumstances, not only is there a tendency to keep livestock production to a minimum, but in addition there is also a natural inclination to maintain such livestock as are kept at a low plane of nutrition. The need, from the national point of view, to avoid keeping livestock on such low planes of nutrition was clearly brought out in the papers and discussion. Thus, Mr. R. W. Pomeroy showed that both the birth weights of lambs and the subsequent milk yields of the ewes are affected by the plane of nutrition of the ewe during pregnancy, a high plane of nutrition in the latter part of pregnancy resulting in a higher birth weight of lamb and an increased milk yield. The experimental results show that it is preferable to maintain a high plane of nutrition during the last two weeks of pregnancy rather than maintain a moderate plane of nutrition throughout the pregnancy period. Under conditions of limited supply of concentrates, the practical importance of these findings in the economical production of fat lambs needs no emphasis. In the case of pigs, the emphasis of the effect of planes of nutrition lies on the treatment of the young pigs rather than on treatment of the sow, the experimental evidence indicating that the best results for pigs reared to 200 lb. live weight are obtained by rearing the pigling for the first sixteen weeks on a high plane of nutrition followed by a low plane thereafter. Similarly, in the case of milk production, Dr. S. Bartlett gave evidence to show that increasing the plane of nutrition of the dairy cow beyond the accepted standards results in reduced efficiency of conversion of food to milk, and that lowering the plane of nutrition below the accepted standard not only reduces the milk yield, but also results in a change in the normal milk composition, the solids-not-fat being reduced below normal.

In the case of fowls, Mr. E. T. Halnan showed that where birds are intended for early slaughter as meat, a high plane of nutrition results in increased growth-rate and consequently a greater efficiency of conversion of food protein to meat protein; high-level protein diets are therefore more economical where slaughter at weights approaching 1¼–1½ lb. are concerned. If, however, the birds are intended for laying or for

breeding, moderate levels of protein feeding are indicated, since birds on moderate planes of nutrition attain similar weights at 33 weeks of age to those reared on high planes of nutrition. For egg production, maintenance of layers at a low plane of nutrition, whether induced by the use of inferior feeding-stuffs, restriction of food consumption, or by the use of bulky or fibrous foods, results in a diminution or cessation of egg production and is consequently uneconomic and wasteful of food.

On the problem of making the most efficient use of available resources, Prof. M. M. Cooper expressed the view that there is considerable room for improvement in the use of grassland, particularly the so-called rough grazings, and estimated that no less than nine million acres of land are capable of improvement. The difficulty of dealing with the hill country, particularly some areas in Scotland, was emphasized during the discussion, in which it transpired that on some hill farms the annual lamb production is 60–70 per cent, and it takes two years for a cow to produce a calf.

With regard to sheep, Mr. Pomeroy suggested that the future of the sheep industry appears to lie in concentrating on the production of fat lamb from cheap grass in the spring and summer, and reserving the more expensive winter feeding-stuffs, hay and roots, for carrying the breeding flock through the winter. In the case of pigs, assuming that the era of cheap imported feeding-stuffs is unlikely to return in the near future, it would be better to spread the breeding-sow population thinly over as many farms as possible, the basic idea behind this policy of 'two sows on every farm' being that, with the provision of the requisite minimum of concentrated food in the form, say, of fish meal, the average farm should be able to supply sufficient food in the form of grass, chat potatoes, tail corn, crop surpluses and the like to support two sows and their progeny.

With regard to milk production, Dr. S. Bartlett suggested that the most hopeful method of increased production in existing circumstances is in the direction of increasing the average yield per cow rather than in attempting to increase the number of cows. A better use of roots in the ration gives some hope of achieving this; in an experiment the daily starch equivalent intake of a cow on a diet of hay and roots was raised from 14·5 lb. to 18·4 lb. starch equivalent by increasing the roots fed from 33 to 99 lb. The kind of roots fed is important, and Dr. Bartlett said that he had been impressed with the dependence placed by the Danes in their dairy production on the use of 'fodder beet', a root crop which in addition to being palatable has a high dry-matter content (approximately 21 per cent). By this increased use of suitable root crops, coupled with the practice of 'steaming up' prior to calving, there is no reason why increased yields of milk should not be obtained on home-grown foods and with present resources.

On poultry meat and egg production in Britain, the future appears to rest, in Mr. Halnan's opinion, on the provision of adequate supplies of cereal grains and cereal by-products. War-time experience on the use of substitutes has shown the very limited capacity of poultry to deal with bulky or fibrous foods, except geese, which considerably increased in number throughout the War. The only feeding-stuff capable of acting as a cereal substitute is potatoes, and these are capable of replacing one-half of the daily food requirements. The use of potatoes is, however, wasteful of fuel and labour, and the suggestion was made that from the national point of view it would be more economical to make available for poultry feeding the 700,000 tons of wheat offal that would arise from a reduction of milling extraction-rate from its present 82 per cent to 70 per cent, rather than to ask poultry producers to increase egg production by using the calculated 2,800,000 tons of potatoes required as a substitute. E. T. HALNAN

FLUORINE AND ITS COMPOUNDS

A SHORT symposium on "Fluorine: the Element and Some of its New Compounds" was held by Section B (Chemistry) of the British Association at the recent Newcastle meeting. Sir Alfred Egerton presided, and in a few opening remarks commented on the rapid progress made in recent years in the chemistry of fluorine compounds.

The first speaker, Mr. H. R. Leech (Imperial Chemical Industries, Ltd., Runcorn), gave a lucid account of the production and techniques of handling elementary fluorine. After dealing briefly with Moissan's original isolation of the element in 1886, he gave an account of the development of different types of cells in Germany, Great Britain and the United States during the past few years. These all involve the electrolysis of a potassium and hydrogen fluoride mixture at high, medium or low temperatures. In most cases, the cells have steel cathodes and either nickel or carbon anodes. In Germany during the War, a fluorine installation built for chlorine trifluoride production had a potential output of 700 tons of fluorine per annum, and the cells running at 250° C. used silver for the electrode material. A good deal of attention was necessary for the successful running of such cells. Fluorine was produced in America in very large amounts for the Manhattan atomic energy project. Modern British and American cells use medium temperatures (up to 90°), and in the British cells polarization troubles have been largely overcome by use of a special form of carbon for the anodes. Mr. Leech outlined the work done in his laboratories on fluorine bubble growth and formation during electrolysis of the molten potassium hydrogen fluoride ($KF.2HF$), and a striking illustration was given of the 'non-wetting' effect of the electrolyte at the carbon anode. Reference was made to the importance of electrode–electrolyte contact angles. Although it has taken sixty years to achieve, it is quite clear that there are now no important technical problems to be solved in the production and handling of fluorine on the largest scale.

Prof. H. J. Emeléus (Cambridge) dealt with some recent advances in the chemistry of certain inorganic fluorides. He outlined the reactions of fluorine with the other halogens, making special mention of chlorine and bromine trifluorides and of iodine pentafluoride, and dealt briefly with some of their chemical properties.

Chlorine trifluoride is a gas, boiling at 11·3° C., which can readily be prepared by burning chlorine and fluorine together under appropriate conditions. It is already available in cylinders from Mr. Leech's laboratories. It behaves as a powerful fluorinating agent and is probably the best means of storing and transporting fluorine. Chlorine trifluoride in the pure state is a non-conductor, though both bromine trifluoride and iodine pentafluoride do conduct. In bromine trifluoride the existence of the ions, BrF_2^+

and BrF_4^-, has been demonstrated clearly by conductiometric methods. Bromine trifluoride can function as an ionizing solvent. Thus, those substances such as $BrF_2^+SbF_6^-$, which contain the BrF_2^+ ion, can act as acids, while those such as $K^+BrF_4^-$, which contain the BrF_4^- ion, can act as bases.

Prof. Emeléus then dealt with a new field of chemistry which he and his colleagues have recently opened up and which clearly demonstrates the overlap between organic and inorganic chemistry. It concerns the use of the halogen fluorides as fluorinating agents for organic substances, and of metallic derivatives of fluorocarbons. Iodine pentafluoride can be used to prepare $Hg(CF_3)_2$, $HgCF_3I$ and $Hg(C_2F_5)_2$. Furthermore, the reaction between iodofluoromethane or iodofluoroethane and olefinic hydrocarbons and fluorocarbons has led to a new range of fluorocarbons of high potential importance.

The final paper was given by Prof. M. Stacey (Birmingham), who considered organic fluorine compounds. He dealt initially with methods available for the introduction of fluorine into organic compounds, discussing first those reactions which do not require the use of elementary fluorine. They involve chiefly the replacement of chlorine, bromine or iodine in an organic halide by agents such as the fluorides of hydrogen, silver, mercury, antimony, etc.; and the merits and special applications of these were demonstrated. The influence and stability of fluorine atoms in different positions and in different groups in certain molecules were outlined, and the point made that, in general, elementary fluorine is necessary for complete replacement reactions to give 'φ' or perfluoro compounds. The methods for using elementary fluorine as a fluorinating agent need either fluorine-inert liquid diluting agents or a metallic catalyst such as gold-plated copper. Other fluorinating methods utilize inorganic fluorides such as cobalt trifluoride or silver perfluoride, which at suitable temperatures readily give the lower fluorides of the metal and atomic fluorine. These methods need further study in order to control them for partial fluorinations. Prof. Stacey also dealt with the polymerization of fluoro- and fluorochloro-ethylenes and -butadienes as initial material for fluorocarbon production. The

stability of the —C—F bond may endow fluorocarbons

with remarkable chemical and thermal stabilities.

Attention was directed also to many of the unusual properties of fluorocarbons, some of which, for example, the 'Freon' refrigerants and the polytetrafluoroethylene plastics, are already in use in industry. Other uses suggested were for non-inflammable lubricants, hydraulic fluids and plastics; heat-transfer agents, fire extinguishers, and so on. The striking properties of trifluoroacetic acid and its derivatives were described, and the highly toxic nature of substances containing the CH_2F—CO groups, as shown by Dr. B. C. Saunders *et al.* in Cambridge, was used to illustrate how important the organic fluorine compounds may become in biology. It appears that a vast new field of organic chemistry and technology is ahead.

During the discussion which followed, numerous questions were asked of the speakers, and the audience gave a great welcome to Dr. N. V. Sidgwick, who mentioned some anomalous properties of certain fluorine metal bonds.

In connexion with the symposium an exhibition of fluorine cells and fluorine compounds was arranged.

M. STACEY

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT FOR 1947–48*

THE thirty-third report of the Department of Scientific and Industrial Research covers the year 1947–48, and is almost exactly half the length of the twenty-third report, the last published report of the Department. That report covered the year 1937–38, and it now appears from a note to the present report that the intervening reports, though prepared and formally submitted to Parliament as required by Order in Council, will not be published.

The present report departs considerably in arrangement and content from the pre-war reports. It includes, like them, indeed, the report of the Committee of the Privy Council for Scientific and Industrial Research, signed by the Lord President, Mr. Herbert Morrison, and the report of the Advisory Council over the signature of its chairman, Sir Geoffrey Heyworth. There are the customary lists of assessors and of members of research boards and committees of the Department, of establishments and research associations, statistics of maintenance allowances, research awards and grants, and the expenditure over the whole period is summarized in the usual form. The lists of departmental publications and of publications by individuals in receipt of grants are not, however, appended, either for the year or for the whole period.

The omission is the more noteworthy in that there is nowhere a clear account of the work of the Department during the particular year under review. Much of the Advisory Council's report consists of a review of the years 1938–48, including sections on the post-war development of existing establishments, on the research associations and on other general or broad topics. Scientific workers and industrialists alike will conclude that if the substance of the intervening reports is, indeed, incorporated in the present report, a miracle of compression has been performed.

The largest section of the report of the Committee of the Privy Council is that dealing with the post-war period. Reference is made to the creation of various new organisations, such as the Pest Infestation Research Organisation, in 1940, the Joint Fire Research Organisation of the Department and the Fire Offices' Committee, in 1946, of a separate Radio Research Organisation to absorb and develop the work of the Radio Division of the National Physical Laboratory, and the creation of a new Mathematics Division of the National Physical Laboratory. As a result of reviews of their fields by each of the existing research boards, proposals have been formulated and generally approved for extending the scope of the Department's other research organisations. Between 1937 and 1947 the number of research associations increased from twenty-two to thirty-five, and their total income from a little more than £400,000 to nearly £2·5 million. The expenditure of the whole Department increased from £682,180 in the year ending March 31, 1939, to £1,239,570 in 1945–46, £1,961,293 in 1946–47, and £2,694,061 in 1947–48. In that year net expenditure on the National Physical Laboratory was £381,327, on building research £203,663, on chemical research £51,073, food investigation £116,571, forest products research £71,477, fuel research £149,815, radio research £85,023, road

* Department of Scientific and Industrial Research. Report for the year 1947–8, with a Review of the Years 1938–48. (Cmd. 7761.) Pp. iv+103. (London: H.M. Stationery Office, 1949.) 2s. net.

research £160,979, Geological Survey and Museum £108,306, research association grants £953,387, and grants to students, etc., £204,373. In his survey, the Lord President lays stress on the way effort has been deflected from extended programmes of basic research, and on the extent to which information and advisory services and short-term investigations dominate the Department's work at present. During the period the total staff of the Department increased from 2,153 in 1939, to 2,944 in 1946, 2,989 in 1947, and 3,090 in 1948.

The report of the Advisory Council begins with a brief historical survey and a short note on the Department's work in preparation for war as well as on its war-time activities. The Advisory Council believes that the decision to maintain the Department and its research stations as units and to devise means for applying their resources in whatever directions the changing needs of war should dictate was right, as was the extension of the policy to cover research teams in industry. The procedure was important in holding together research units used to attack special problems arising out of technical developments in warfare. Commenting on the work of the Department in war-time, the Advisory Council refers to the degree of adaptability shown by scientific workers, and this characterized, perhaps in even greater degree, the university scientific men who entered Government research establishments. Brief references are made to the Department's part in the development of the atom bomb and to its pioneer work on radar, but not all the peace-time researches were abandoned. In May 1944 a committee, with Sir Frank Smith as chairman, was appointed to review the whole scope, policy and activities of the Department in relation to post-war needs. Reporting in October 1944, this committee suggested that the needs of firms too small to maintain research staffs of their own required examination and that these needs might be met by a scheme of industrial fellowships. Special consideration of the need for research in mechanical engineering, for more fundamental research on radio, the inclusion of a programme of deep boring as a normal feature of the work of the Geological Survey, and the consideration of formal arrangements for sociological research were also recommended.

Generally, in considering this report, the Advisory Council formed the opinion that the chief need of the Department was that it should equip itself to take the initiative in giving advice and assistance to industry in the use of scientific research and in ensuring that the potential industrial value of new discoveries in science would be recognized and explored without delay. For this purpose a considerably enlarged central Intelligence and Information Division has been established which represents a charge of £23,978 in the year 1947–48. It was decided as a result of inquiry by a special committee, under the chairmanship of Mr. W. F. Lutyens, to leave open for review the question of arrangements for meeting the needs of small firms; but the adoption of proposals for increasing the activities of the Geological Survey involves an increase in expenditure from the 1938–39 figure of £75,000 to about £200,000, with a further £300,000 over five years for the deep-boring programme. Expansion of the work of the Fuel Research Station to a level of £250,000–£300,000, including the work undertaken by the Department on atmospheric pollution; of the Food Investigation Organisation to an eventual £150,000, including doubling the size of the Torry Research Station, Aberdeen; of that of the Building Research Station to at least £250,000 for the next few years; and of the Chemical Research Laboratory to an ultimate scale of £150,000, as compared with £26,000 pre-war, are also recommended. Other proposals approved include those for a new radio research station with a scientific staff of 160 and an eventual annual expenditure of £225,000; for the expansion of work on forest products to a level of £100,000; on the Water Pollution Research Laboratory from the pre-war £9,000 to £50,000; on the Road Research Laboratory to £250,000; while the new Mechanical Engineering Research Laboratory at East Kilbride will call for expenditure of £250,000–£350,000 per annum. The new Fire Research Organisation is expected to operate at a level of about £50,000 per annum, and the Pest Infestation Research Laboratory to a similar level. A review of civil engineering and hydraulics research by a committee under the chairmanship of Sir William Halcrow indicated that the chief gap was in the provision for research on marine works and waterways, and the Advisory Council has approved the committee's recommendation to establish a Hydraulics Research Organisation to operate on a scale represented by expenditure of about £45,000 per annum.

These plans represent an estimated annual expenditure of £2·1 million, and with £500,000 for the National Physical Laboratory and £150,000 for headquarters administration and overseas liaison, bring the figure for the Department's own research programmes at 1946 rates to some £2·75 million. With grants to research associations of £1 million and scientific grants at £100,000, the expenditure of the Department is put at the round figure of £4 million at the costs then ruling. Comparison of this total and of the individual items with the figures already cited shows how far from realization are these planned developments. Rising costs invalidate a strict comparison of figures, and the report emphasizes that staff numbers give a more accurate measure of the advance already made. The scale of expenditure planned represents, at 1946 rates, an increase in the staff of the Department's own organisations from 2,750 to something more than 5,000. The 1948 figure already quoted represents an annual increase of about 170 a year, and unless this rate of expansion is improved it will be many years before the plans can be realized.

Grants to research associations in 1947–48 almost reached the estimate and represent a substantial expansion even when allowance is made for rising costs. A lengthy section of the report reviews the broad policy pursued towards research associations, but it will suffice here to quote the Advisory Council's opinion that it is satisfied that the research association is a sound and effective way of bringing science and industry together. Grants to students and research workers during 1947–48 were double the estimate, but a large proportion is for grants for nuclear physics research, and the Advisory Council, pointing out that the policy of awarding these grants has become more liberal, believes that the grants are achieving their aim of giving full opportunity to potential scientific leaders.

The chief factors limiting the development of the Department's plans have been shortage of staff and lack of suitable buildings, and the Advisory Council clearly recognizes that the Department's claims have to be considered in relation to other claims on the nation's resources. Most of the projects which have had to be set on one side are long-range investigations

designed to further our knowledge and understanding of basic principles. The Advisory Council emphasizes in conclusion, however, that the question of striking the right balance between short-range and long-range work, of balancing the need for giving assistance on problems of immediate and pressing importance and the need for providing the basis for more far-reaching advance in industrial technique and practice, on which the continued prosperity of the country must ultimately depend, is the major problem of policy at the present time and is likely to remain so while staff and facilities are limited.

OBITUARIES

Prof. Birbal Sahni, F.R.S.

PALÆOBOTANISTS in many countries heard with regret the news of the sudden death of Birbal Sahni on April 10. His slight figure, his modest personality and polished manners were well known at international gatherings of botanists and geologists; few Indian men of science can have been more widely respected. He was not only a diligent research worker but also a stimulating teacher and a good organiser. He did much to develop his own subject and the cause of natural science in India.

He was born in 1891, the son of Prof. R. R. Sahni, and was educated at Lahore and Cambridge, where he held a Foundation Scholarship at Emmanuel College. After graduating in 1914, he began research under Prof. A. C. Seward on living pteridophytes, gymnosperms and their fossil ancestors. This led to a series of remarkably able papers, several of which were published in the *Philosophical Transactions of the Royal Society*.

Returning to India in 1919, Sahni became professor of botany at Benares for one year, then moved to Lahore, and in 1921 went to Lucknow, where he remained for the rest of his life. There he carried out a long series of investigations on the fossil plants of India, and gathered around him a band of enthusiastic young workers in the same field. New discoveries were made in many different areas, which contributed to knowledge of the vegetation of past ages and often indicated the geological age of the plant-bearing rocks. In recent years he developed the study of micro-fossils and carried out an intensive study of the minute organic remains in the Saline Series of rocks in the Salt Range. These rocks had often been regarded as of Cambrian or Pre-Cambrian age, owing to their occurrence in the field, but they were found to contain a wide variety of micro-fossils which could not be older than Tertiary.

Sahni played a large part in the development of scientific societies in India. He was one of the founders of the Indian Botanical Society and was its president in 1924. He was president of the Indian Science Congress in 1940, twice president of its botanical section and once of its geological section. He had been foreign secretary and president of the Indian National Academy of Sciences. He was awarded the degree of Sc.D. at Cambridge in 1929 and was elected a fellow of the Royal Society in 1936. At the International Botanical Congresses of 1930 and 1935, he was a vice-president of the Palæobotany Section.

During the last ten years Sahni devoted much time to the organisation of an Indian Institute of Palæobotany. Considerable progress had been made with this scheme, and its activities had commenced. A new building to accommodate collections, library and research workers was planned, and its foundation-stone was laid by the Prime Minister, Pandit Nehru, on April 3. It is hoped that this Institute will be a lasting memorial to the distinguished man who was its founder and first director. Sahni was married to a beautiful and talented wife who was his constant companion and helper, and who now presides over the governing body of the Institute.

H. HAMSHAW THOMAS

Prof. G. H. Henderson, O.B.E., F.R.S.

GEORGE HUGH HENDERSON, O. E. Smith professor of physics, Dalhousie University, and chief superintendent of the Naval Research Establishment at Halifax, died suddenly at the age of fifty-six on his way to a New Brunswick fishing camp. He is survived by his wife, Ruth Wallace Ross Henderson, and two daughters, Nancy and Margaret, the former a science student at Dalhousie.

Chiefly as a result of over-work during the War, his health became seriously impaired in 1944, but he would not give up work until he had a serious breakdown in March 1948. He partly recovered, but still refused to take life more easily. During the last two weeks of his life he took part in the meetings of the Royal Society of Canada, presenting six papers, and attended meetings of the Defence Research Board and the National Research Council.

Prof. Henderson received his B.A. and B.Sc. degrees from Dalhousie University in 1914 with high honours in physics and the Governor-General's Gold Medal. Two years later he received his master's degree and was awarded an 1851 Exhibition research scholarship. Three years later he proceeded to the Cavendish Laboratory, Cambridge, and in 1922 obtained his Ph.D. there. He then went back to Canada as a professor at the University of Saskatchewan, and in 1925 returned to his Alma Mater as professor of mathematical physics. He became a Fellow of the Royal Society of Canada in 1927, and in 1941 was elected to the Royal Society of London.

Prof. Henderson's strong sense of duty led him to serve his country during the two World Wars—in the first as an engineer officer in the Army, and in the second he gave outstanding service to the Royal Canadian Navy in his capacity as a physicist and also in the field of operational research. For his outstanding contributions as superintendent of the Naval Research Establishment he was made an O.B.E. in 1943.

The first of Henderson's twenty-five scientific papers was published while he was still an undergraduate. It was in the comparatively new field of radioactivity, which continued throughout life to be his major research interest. His study of pleochroic haloes and his development of a new method for estimating the age of minerals containing them attracted much attention from both physicists and geologists.

Not only was Prof. Henderson a scientific investigator, but he was also an able teacher. He was revered by his students. He never spared himself and was always ready to spend time and trouble to help serious students. Two characteristics in his character stand out which would seem to conflict but did not. He was an individualist, independent, did his own thinking and made his own decisions.

On the other hand, he was a real conservative, educationally and otherwise. He did not believe in change for change's sake. He had little use for some modern educational ideas—for science taught without mathematics, and literature without languages. His interest in literature and art was second only to his interest in science. He also possessed excellent administrative ability, which he generously gave to the many scientific organisations to which he belonged, such as the National Research Council of Canada, the Nova Scotia Research Foundation, and the Nova Scotian Institute of Science, of which he was a past president.

Prof. Henderson's place in physics in Canada cannot easily be filled. His great intellectual ability, his unusual discrimination and his modesty won for him the respect and esteem of all who knew him. He permitted his love for his profession to interfere with the proper regard for his health. His untimely end is a sad loss to Canada. On the day of the funeral service at Halifax, not only were the University flags at half-mast, but so also were those of all the ships and establishments in the Atlantic Command of the Royal Canadian Navy. J. H. L. JOHNSTONE

Prof. Elton Mayo

THE recent death of Elton Mayo, until his retirement professor of industrial research in the Harvard School of Business Administration, is a great loss to the social sciences. 'Social sciences' is used advisedly in the plural, because Mayo's qualifications and his main work lay in the borderland between economics, social psychology, psychiatry, social anthropology and, to some extent, political science. The experiment at the Hawthorne Works, Chicago, of the Western Electric Co., for which he and his team of collaborators are so justly famous, not only integrated several divisions into which the study of man has threatened to split, but also shifted the emphasis. As I wrote, when reviewing one of the publications of this team, "the general argument of the authors may fairly be summed up in the two propositions that psychological factors are more important than physiological, and that sociological and anthropological factors are more important than economic".

Elton Mayo was himself quite conscious of the new emphasis. In his brief "Social Problems of an Industrial Organisation", published in 1945, he made the point that: "the ordinary conception of management–worker relation, as existing between company officials, on the one hand, and an unspecified number of individuals, on the other, is utterly mistaken. Management, in any continuously successful plant, is not related to single workers but always to working groups. In every department that continues to operate, the workers have—whether aware of it or not—formed themselves into a group with appropriate customs, duties, routines, even rituals; and management succeeds (or fails) in proportion as it is accepted without reservation by the group as authority and leader".

Mayo can be reckoned as one of the forces which, together with anthropology, is putting sociology back on the map; indeed, Mayo's approach was partly that of the anthropologist. He differed from previous investigators in the industrial field in studying a small face-to-face group intensively and 'all round'. One of his pupils, North Whitehead, wrote a 450-page book about half-a-dozen girls, and in his "Management and the Worker" another pupil, Prof. Roethlisberger, devoted 150 pages to a group of fourteen bank-wirers.

But Mayo did not, to his credit, rely on one approach. He and his team also used the mass interview, with statistical measures to give summary generalization.

These mass results were not mechanically interpreted. Mayo used statistics as a box of tools, and only as *one* of his boxes of tools, and the answers were treated as psychiatric data rather than as a record of facts about the factory organisation. In his first book on the Hawthorne inquiry, "The Human Problems of an Industrial Civilization", published in 1933, Mayo has a most illuminating chapter on the "Measuring of Morale", in which he stresses the importance in factory life of minor forms of obsessive thinking. "Janet's demonstration of the mentally shattering effect of an experience of personal incapacity seemed to provide a possible clue to a better interpretation of the distorted statements about persons in many interviews." This psychological insight into the mass answers, together with the intensive observation of the small group, led Mayo and his colleagues in the subsequent course of their inquiry to discover the differing worlds of thought prevailing in a factory at different levels—a most important discovery wherever productivity per man is affecting the standard of living. For it appears to be particularly the workers at the spear-head of production who do not care about production. One rule in the Hawthorne bank-wirers' code of thought and conduct was not to work too hard—not to be a 'rate-buster'.

Mayo's important conclusions are put forward in his books and articles and in those of his pupils in an easy style, full of delightful quotations out of the workers' own mouths; and, for those who had the pleasure of listening to Mayo, as I did as recently as last winter, his quiet reminiscent style was captivating. But his books are far from mere anecdote. A system of thought embodying his many-sided approach is implicit and often explicit in his work.

P. SARGANT FLORENCE

WE regret to announce the following deaths:

Mr. William Binnie, past president of the Institution of Civil Engineers, on October 4, aged eighty-two.

Prof. Major Greenwood, F.R.S., emeritus professor of epidemiology and vital statistics in the University of London, on October 5, aged sixty-nine.

Dr. A. P. Laurie, formerly principal of the Heriot-Watt College, Edinburgh, and professor of chemistry to the Royal Academy of Arts, on October 7, aged eighty-seven.

Mr. C. E. Muriel, conservator of forests (Bengal) during 1910–16, on October 5, aged eighty-eight years.

Dr. E. W. Posnjak, formerly of the Geophysical Laboratory, Carnegie Institution of Washington, on August 5, aged sixty-one.

Prof. Edwin B. Powers, professor and head of the Department of Zoology, University of Tennessee, known for his work on the physiology of fishes, on August 26, aged sixty-nine.

Dr. Frank Thone, biology editor of Science Service, Washington, D.C., which he joined in 1924, on August 25, aged fifty-eight.

NEWS and VIEWS

Physics at St. Bartholomew's Hospital Medical College : Prof. J. Rotblat

DR. J. ROTBLAT, who has recently been appointed to succeed Prof. F. L. Hopwood in the chair of physics at St. Bartholomew's Hospital Medical College, London, is Polish by birth and was educated in Warsaw, graduating at the Free University of Poland. His first research was on the properties of gases at low pressures, but he soon turned to nuclear physics, working under the direction of Prof. Wertenstein. In 1936 he was awarded the degree of doctor of physics and became assistant director in the Department of Atomic Physics, in the development of which he took an active part. Dr. Rotblat came to Great Britain in the spring of 1939, to work in nuclear physics at Liverpool, where, except for a period of war work in the United States, he has since remained. From the beginning of the War, he took an ever increasing part in the work of the Physics Department at Liverpool, showing outstanding ability in teaching as well as in research. He made valuable contributions to the development of atomic energy in Great Britain, by his own work and by his leadership of a research group. His administrative capacity has been shown in his work as chairman of panels of the Nuclear Physics Committee, one for the promotion of the photographic emulsion technique and the other for the co-ordination of work on new cyclotrons; above all, perhaps, in his work on the Atom Train Exhibition, the success of which was largely due to him. In the past two years Dr. Rotblat's research interest has turned towards the medical applications of physics, more especially the use of radioactive isotopes, a line of work which should find ample scope for development in his new post.

International Council of Scientific Unions

THE report of the Executive Committee of the International Council of Scientific Unions for 1948 (from the General Secretary, at Gonville and Caius College, Cambridge. Pp. vii+110. 5*s*.) forms the usual indispensable reference work on the work of the Unions, listing as it does not only the membership of the Committee, and the adhering Organisations of the Council, but also the reports from the several Unions and Mixed Commissions and new statutes. This year's report gives the modification in the statutes of the International Astronomical Union and the International Union of Pure and Applied Physics, and the new statutes of the International Union of Chemistry and the International Radio-Scientific Union. The report includes under the title of "Science and Peace" an analysis of the seventy replies to the two questions on this subject sent out to representative men of science as a result of the June 1948 meeting of the Commission for Science and its Social Relations (see *Nature*, **162**, 237; 1948; and **163**, 190; 1949). Among other points of interest in the report is the resolution sent by the Executive Committee to the United Nations Educational, Scientific and Cultural Organisation and to adhering organisations and for which support from the General Assembly of the Council is being requested. This resolution stresses the importance of the unimpeded passage of scientific workers from one country to another for attending meetings of recognized scientific bodies, for visiting places of research or instruction or for other forms of international scientific contact. The Executive Committee offers its help in facilitating the work of consulates when in doubt about granting a visa by naming the national adhering body which is best qualified to certify that the applicant is a *bona fide* scientific worker and that his application is for a genuine scientific purpose. A first report from the International Union for the History of the Sciences, formed on October 31, 1947, is included.

Developments at the University of Bratislava

FOUNDED in 1919, the University of Bratislava had no science faculty until 1946, though the natural sciences were taught as part of the medical courses. Recently, much progress has been made, and there are more than two hundred students reading for degrees in science. Among others, the Plant Physiological Institute is well organised and conducts advanced studies, and research work is being undertaken by Dr. L. Pastyrik, who is studying the composition of plant ash in relation to the elements occurring in the soil, thus following the work of Prof. B. Němec. The newly established Wood Research Institute, under the direction of Dr. J. Travnik, is a large building, and, though still short of equipment, is conducting investigations especially on the utilization of waste and on the metallic impregnation of beechwood; its library and documentation service are already proving useful. The extensive Slovak forests have hitherto been wastefully exploited, and attention is being directed towards the best means of utilizing timber resources. This Research Institute is staffed mainly from the University but is independent of it.

Bratislava is to have a comprehensive Technical University, now half completed, covering several acres and consisting of laboratories for chemical technology, electricity, pure and applied physics, fermentation and biochemistry, as well as a large engineering department. Among recent investigations conducted at Bratislava are some by Dr. P. Němec on the antibiotic substances occurring in higher fungi. Extracts from several species of *Polyporus*, especially *P. sulphureus*, are strongly antibiotic to certain bacteria, for example, *Bacillus coli*. Not all species of *Polyporus* contain the antibiotic principles, however. An interesting development of the work was the observation of a similar bacteriostatic effect obtained from excreta of herbivorous animals, provided the excreta had been left some days until spores of higher fungi had germinated on them. Dr. Němec has isolated an actinomyces, provisionally denoted *M*-VII, the antibiotic effect of which is known to be directed against *Staphylococcus pyogenes aureus* (line *o*) but not against *B. coli* or the Mycobacteria.

Seismology in the Americas

AT the Fourth Pan-American Consultation on Cartography held at Buenos Aires, Argentina, in October 1948 under the auspices of the Pan-American Institute of Geography and History, a resolution was adopted requesting the Institute to create a committee to promote and co-ordinate seismology among American countries. This committee is to establish a central office of information, form a library, maintain a secretariat and scientific staff, and to interchange data with interested world agencies. It is expected that this will give fresh impetus to American seismological activity and international co-operation.

Appropriate action has already been taken with the setting up of a sub-committee on seismology within the organisation of the Commission of Cartography of the Pan-American Institute of Geography and History. Interested nations have been invited to designate committee members, and Dr. Federico Greve, director of the Seismological Institute of the University of Chile at Santiago, has been appointed president. The Seismological Institute has undertaken to provide the necessary library and office space and will assign suitable personnel to carry out the work of the sub-committee. Engineering seismological work, with the object of improving structural design practice, will be prominent in the programme already undertaken by Dr. Greve in view of the grave importance of this matter in the seismically active Andean region. The Seismological Institute has built a number of strong-motion accelerographs for field-study of the motions characteristic of destructive earthquakes.

Germination of Yezo Spruce Seed

A MONOGRAPH of 140 pages has been published dealing with physiological studies on the germination of Yezo spruce seed (*J. Fac. Agric.*, Hokkaido Imperial University, Sapparo, Japan, 1942). The investigations were carried out on the germination of seeds of *Picea Glehnii* and *Picea jezoensis*, and deal with the absorption of water and non-electrolytes, swelling, suction force, change of reserve material and the germination capacity. It is stated that the salts which cause the greater absorption of water by seed grains do not always promote their germination, whereas the concentration of non-electrolytes has a great effect on the germination of the seed. Perhaps a practical point of interest is the statement that temperature plays an important part in the germination of both of the *Picea* seeds, combined with the amount of water available. A temperature higher than 25° C. is unfavourable for germination, whereas a temperature lower than 10° C. exerts no injurious effect upon the germinative capacity of the seeds, since seed was submerged in cold water at that temperature for a long period without loss of germinating power. These facts suggest, it is held, that the climatic conditions of Hokkaido are suitable for the development of the *Picea* forest. It is quite a common event for the *Picea* seeds to be buried under snow and submerged in cold water for as long as five months without any loss of their germinative capacity.

Primitive Vertebrate

THE Placoderms are of considerable interest to the palæontologist, since they are the earliest of the gnathostomatous vertebrates. In 1934, Erik A:son Stensiö published the first part of a monograph of this sub-class, with supplements in 1936 and 1939. The present work (on the Placodermi of the Upper Devonian of East Greenland, published as Bd. 139 of the Meddelelser om Grønland udgivne of Kommissionen for Videnskablige Undersøgelser i Grønland. Pt. 1, pp. 662 with 308 text figs.; Pt. 2, 77 plates (København: C. A. Reitzels Forlag, 1948.) 55 Kr.) constitutes the second part of the monograph and treats of the sub-family Bothriolepinæ, in which two genera, *Bothriolepis* and *Grossilepis* gen. nov., are recognized. The order Antiarchi, to which the sub-family belongs, appeared in the Middle Devonian and became extinct in the Upper Devonian. While off the main line of vertebrate evolution, the order was probably derived from early, primitive Euarthrodires and deserves notice because of its high specialization. The author considers that the order falls into two groups, which he names the Asterolepiformes and the Bothriolepiformes, and the Bothriolepidæ form one of the four families of the second group. The work is divided into two parts, the first being a detailed description of the anatomy of the subfamily with a discussion of the homology of the bones, and the second is a full account of all previously described forms and a revision of their systematic position. Undoubted remains of pelvic fins have been found. The work is characterized by its comprehensiveness and by the meticulous care that one has learned to associate with the author's previous publications. It is valuable not only on account of the considerable additions to our knowledge of the subfamily, but also because it gives command of all previous work in the same field.

A Rookery in Winter

DURING the last fortnight of 1947, C. M. Ogilvie made observations at a rookery which had been first built in 1946 in a small beech copse within a few hundred yards of two larger colonies. For four days the behaviour of the birds was closely watched, and in the March issue of *British Birds* (42, No. 3; 1949) Mr. Ogilvie summarizes his observations. The colony was visited by rooks within two hours of dawn every day and, except on two occasions, was finally deserted at least five hours before dusk. The number of birds varied considerably during the day, and jackdaws were rarely present. Though displaying no pairing or nesting tendencies, the majority of birds indulged in group flights and other activities associated with considerable mutual excitement. Several paired birds regularly occupied the nest remnants and frequently, but not invariably, defended their territory; a preference for certain nests and the neglect of others were noted. Observations also showed that 'nesting' rooks indulged in pairing and courtship activity, bill-fondling, mutual preening and ritual feeding, but coition never took place and nest construction was not attempted. The birds appeared to derive a considerable amount of food from the nests. Variation in weather conditions did not obviously influence the behaviour of the rooks or the duration of their visits to the colony. The article concludes with speculations as to the significance of Mr. Ogilvie's recorded impressions.

Permian Glaciation in São Paulo, Brazil

A PAPER by Octavio Barbosa and F. M. de Almeida, which deals with representative beds of the Permian glaciation in the State of São Paulo, Brazil, has appeared in *Anais da Academia Brasileira de Ciencias* (Rio de Janeiro, 1949) under the title, "Nota Sobre A Estratigrafia Da Série Tubarão Em São Paulo". In 1908 the 'Tubarão Series' was shown by I. C. White to exist in the coal measures region of the State of Santa Catarina. This series was composed of lower glacial beds and upper fluvio-glacial, lacustrine and swampy beds with coal. Later on, Euzebio P. de Oliveira separated the lower glacial beds in a new series named Itararé, and detailed research in the Tietê basin, São Paulo, showed that the Itararé–Tubarão Series comprises five formations: (*a*) Itapetininga formation, probably entirely marine; (*b*) Tietê formation—fluvio-glacial, swampy and glacial, with *Glossopteris* flora and coal; (*c*) Gramadinho formation—glacial and fluvio-glacial; (*d*) Capivarí formation—marine, with

invertebrate fauna so far unknown in southern Brazil; (c) Itú formation—glacial and fluvio-glacial, with *Glossopteris* flora and coal. The Tatuí beds do not contain coal and are higher in the Itapetininga formation, and Oliveira has shown that the Itararé beds are not a uniform and undividable sequence of glacier sediments.

New Education

BELIEVING that most educational publications are seldom read by those outside the profession, a group of interested people has founded a publication called *New Education*. It has been designed to interest a wider public in education and its relation to the individual and society and, in divers ways, to bring enlightenment and life to what the sponsors suggest is often a dull subject. It is intended that the new journal shall be concerned with education in all its aspects at school, home, university, and beyond, and will deal with theory, practice and speculation. Among the articles in the first issue, for example, is one by Prof. James Drever on "Psychology and our Schools". Others deal with "The American College" and "Beyond the Classroom", while A. S. Neill, the founder of Summerhill School, discusses "Emotion and Scots Education". These and other articles are well written; but it is doubtful if they will appeal to any body of readers outside that which already reads existing educational journals. The use of illustrations, the inclusion of educational news items and a reduction in price will all be necessary if this journal is to succeed in a venture which is wholly admirable. There are no fixed dates for publication of *New Education*. The first issue may be obtained from New Education Press, 94 Bellevue Road, Edinburgh, 7, price 1*s*. 6*d*.

Library of the British Scientific Instrument Research Association

A CATALOGUE of the books in the library of the British Scientific Instrument Research Association has been compiled by Miss J. M. Fulford, until recently the librarian of the Association, and issued in booklet form for distribution to members of the Association and to a limited number of other organisations and individuals. The printed catalogue comprises sixty-two pages, consisting of a classified catalogue arranged in accordance with the Universal Decimal system (pp. 3–48), an alphabetical index of subjects (pp. 49–52), and an alphabetical index of authors (pp. 53–62). All the catalogue entries list, in order, the author's name, the title and sub-title of the book, the publisher, the date of publication and the number of pages. In addition, an indication is given as to whether the book contains a bibliography, and/or photographs, tables and diagrams. The catalogue is complete up to March 1949. Supplements to the catalogue will be published, at intervals, in the *Bulletin* of the Association.

Pleistocene Wallaby Tooth from Australia

Records of the Australian Museum (**22**, No. 2; 1949) includes an article concerning the supposed human molar from the Wellington Caves of New South Wales. The tooth, first described in 1870, has been discussed by many authors since that date, all of whom accepted the human origin of the fragment. Dr. H. H. Finlayson has recently re-examined the fragment and is of the opinion that it was derived from the Pleistocene macropod *Macropus*, a giant wallaby, remains of which are already known from the Wellington Caves (see also *Nature*, August 14, 1948, p. 256).

Recent Developments in Museums

IN the *Journal of the Royal Society of Arts* of August 12, Mr. Edgar Kaufmann, jun., writes on "Museums and Industrial Design" and describes the manner in which American museums aid and illustrate modern industrial design. In the issue of September 9, Dr. Iorwerth Peate describes the folk museum movement on the Continent of Europe and in Great Britain with especial emphasis on the pioneer work that has been carried out at St. Fagans, near Cardiff.

Tenth International Ornithological Congress

THE Tenth International Ornithological Congress, the first to be held since the War, will take place in Uppsala during June 10–17, 1950. Dr. A. Wetmore, of the Smithsonian Institution, Washington, is president, and Prof. Sven Horstadius, of the Zoological Institute, Uppsala, is general secretary. The preliminary programme of the Congress and details of travel arrangements for British members may be obtained from Miss Phyllis Barclay-Smith, Hon. Secretary, British Ornithologists' Union, c/o British Museum (Natural History), Cromwell Road, London, S.W.7. The Congress will be preceded by a world Conference of the International Committee for Bird Preservation, also the first to be held since the War, though the European Continental Section has held two international conferences, in London in 1947 and in Paris in 1948.

Irish Chemical Association

AT the annual general meeting of the Irish Chemical Association, held in Dublin on September 28, the following officers and council were elected for the 1949–50 session: *President*, D. Crowley; *Vice-President*, W. V. Griffiths; *Honorary Secretary*, G. F. O'Sullivan; *Honorary Treasurer*, M. J. Cranley; *Council*, Miss D. Hurley, V. C. Barry, J. G. Belton, Dr. T. G. Brady, Prof. W. Cocker, Prof. T. Dillon, F. T. Riley, Prof. T. S. Wheeler.

Announcements

PROF. ERIC ASHBY, Harrison professor of botany in the University of Manchester, has been appointed president and vice-chancellor of Queen's University, Belfast, in succession to Sir David Keir. Prof. Ashby takes up his new appointment on September 1, 1950.

THE University of London has conferred the title of professor of education with special reference to education in Colonial areas on Dr. Margaret Read, in respect of the post held by her at the Institute of Education.

DR. T. F. DIXON has resigned from the chair of biochemistry in the Royal Faculty of Medicine, Baghdad, Iraq, and has taken up an appointment as biochemist to the Institute of Orthopædics, Royal National Orthopædic Hospital, London.

THE following appointments in the University of Birmingham have recently been announced: T. Lindhard (University Institute of Theoretical Physics, Copenhagen) to be research fellow in mathematical physics; W. J. Swiatecki to be research fellow in mathematical physics; Dr. B. N. Cole to be lecturer in mechanical engineering; W. Rostoker (Toronto) to be lecturer in industrial metallurgy.

RAPID ASSESSMENT OF VIRUS HÆMAGGLUTININ BY THE AID OF CENTRIFUGAL AND CENTRIPETAL EFFECTS

By Dr. F. HIMMELWEIT
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THE method described by Hirst[1] for the estimation of the hæmagglutinating activity of influenza virus suspensions and its modifications depend on gravity as the main operative force, which either determines the degree of clearance of the suspensions[1], or promotes the development of typical patterns at the bottom of the tubes[2].

Attempts were made to accelerate the process of pattern formation, which takes 1–2 hr., by means of the centrifuge and of a specially designed apparatus which produces anti-centrifugal effects and has been termed, therefore, a 'Centripete'.

In the first series of investigations the suspensions, prepared as for the Salk test[3], were centrifuged in an International Equipment Co. centrifuge, size 1, type *SB*, and then tilted[2] to facilitate the estimation of end-points. Conditions were varied systematically until it was found that centrifuging for 45 sec. and tilting for 30 sec. at an angle of 20° provided the best results. The titres, under these conditions, differed only slightly from those obtained in comparative experiments with the Salk test, but small fluctuations in the applied centrifugal forces in repeat runs reflected themselves in the values. It appears, therefore, that a centrifuge capable of running at constant low speeds would be necessary to obtain reproducible results.

The shortcomings of this procedure were overcome in subsequent investigations by the aid of the 'Centripete', which consists essentially of a wobble-plate mechanism (Fig. 1). This apparatus not only gives reliable results in a very short time but also enables the titration of virus hæmagglutinins or of agglutination-inhibiting antibodies to be carried out on small amounts of material.

To titrate agglutinins, 0·1 ml. volumes of a suitable blood corpuscle suspension[1] are added to equal volumes of serial twofold dilutions of the virus suspension, measured into flat round cells on a glass plate. The plate is first rocked by hand for 30 sec. to ensure an even distribution of the cell contents. When the suspensions are then submitted to a 'run' on the wobble-mechanism, patterns appear within 3 min., which occupy the central area of the cells and exhibit a gradation of features corresponding to the diminishing activity of the falling virus concentrations (Fig. 2).

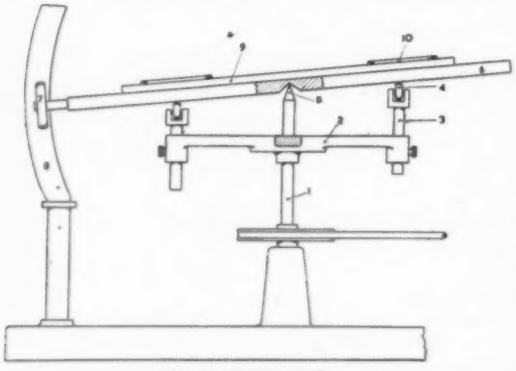

FIG. 1. 'CENTRIPETE'

1, main-shaft; 2, three spokes attached to main-shaft; 3, adjustable spindles; 4, rollers attached to spindles 3; 5, apex of steel cone; 6, wobble-plate centred on apex of cone 5 and resting on rollers 4; 7, roller attached to wobble-plate; 8, guide plate; 9, glass plate; 10, rings of stoving enamel, 20 mm. internal diameter, on glass plate 9

When the main-shaft is rotated, parts 2, 3 and 4 act as a swash-plate mechanism and cause the plate 6 to wobble about the apex of cone 5, rotation being prevented by roller 7 bearing against guide-plate 8

This effect is due to the 'oscillating' motion of the mechanism which accelerates the agglutination process and imparts, at the same time, a centripetal motion to the corpuscles and rapidly forming aggregates, which drift to the centre of the cells at speeds proportional, within a wide range, to their size.

The characteristic feature of the resulting patterns is the presence of disks which decrease in size and granularity as the concentration of the virus falls. In the higher virus concentrations they contain all the available corpuscles, but from an easily recognizable point onwards, the now smooth-looking disks are surrounded by uniformly growing halos of non-agglutinated or only slightly agglutinated corpuscles. The abrupt change in the appearance of the patterns permits the adoption of a convenient titration end-point. This is taken as the geometric mean of the two dilutions, which give, respectively, the last disk with a sharp outline and the first with a halo. More accurate titres are obtainable if the dilution ratio is made closer than 1 : 2. For this purpose, four or five dilutions in steps of a geometric series can be interpolated in a subsequent 'run' between the two dilutions first indicated. The titration of antibodies or other neutralizing agents is performed in accordance with published procedures[1,4], end-points being determined by the criteria employed in the assessment of agglutinin.

The degree of definition in the patterns and the time required for their full development are determined mainly, but not entirely, by the amplitude, frequency and number of the 'oscillations' imparted to the test suspensions. The reproducibility and reliability of results are therefore dependent on constant conditions and necessitate the use of a governed motor, a revolution counter and a time switch. Equally important in the design of the apparatus is the placing of the wobble-plate as close to the centre of motion as possible. The necessity for this derives from the nature of the wobble motion and the factors and conditions giving rise to the centripetal effect.

The motion of the wobble-plate consists of a continuously shifting tilt, given to the non-rotating plate in such a way that its centre-point remains stationary and the normal to the plate through the centre of motion describes a circular cone with a constant angular velocity. The main movement of each point on the plate is a vertical harmonic motion, the amplitude of which depends on its distance from the centre and on the tilt angle. These two factors also determine the additional, though small, radial and tangential displacement to which the given point

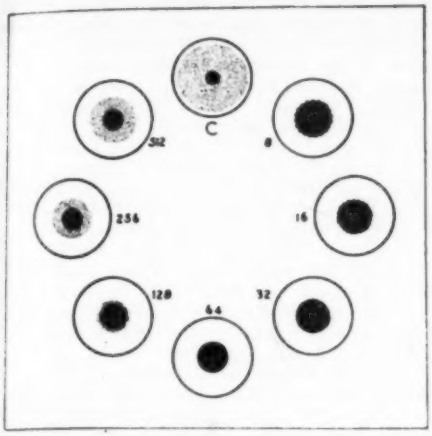

FIG. 2. TITRATION OF VIRUS HÆMAGGLUTININ BY THE AID OF THE 'CENTRIPETE'

Schematic representation of patterns formed by red blood corpuscles in dilutions of infected allantoic fluid (*P.R.* 8 strain of influenzæ virus *A*) and in virus-free diluent (C)

Final virus dilutions 1 : 8 – 1 : 512 ; final chicken corpuscle concentration 1 per cent ; angle of tilt 2° ; r.p.m. of main-shaft 100 ; duration of 'run' 3 min.

Estimated titre of allantoic fluid (geometric mean of dilution factors 64 and 128) = 91

is subjected, but a line fixed in the plate is constrained to move in a vertical plane. If the centre of motion does not lie exactly in the plane of the plate, each point will further describe a horizontal circular motion which is added to those just mentioned. The radius of this circle is $d \sin \alpha$, where d is the distance from the wobble-centre to the plane of the plate and α the tilt angle.

The wobble motion causes the fluid in a cell to flow continually to its momentarily lowest point, where it is deflected by the water-repellent cell wall. Thus rotational flow is generated within a non-rotating container, provided that for a given value of α, which must not be too small, the speed of the main-shaft does not exceed a certain limit. In the circulating bulk of the liquid, the pressure increases radially to a greater extent in the upper layers than in the layer close to the bottom, where the flow is slowed down by friction. The pressure difference in the peripheral zone causes an influx of fluid into the bottom layer, and in the centre a compensating efflux into the upper low-pressure areas. The superposition of the resulting radial circulation and the main rotational flow produces in the bottom layer a close spiral centripetal flow-path, and at the surface widely spaced centrifugal streamlines of a similar character. These two fields of flow are easily rendered visible by allowing blood corpuscles to sediment completely in isotonic sodium chloride solution and by floating lycopodium powder on the surface of the liquid before setting the plate in motion. Both the unaffected and the agglutinated corpuscles which reach the boundary layer on account of their weight thus follow the flow of the fluid to the centre, where they merge into disks. The rising current in the central area carries these upwards until they reach a position close to the surface, where they remain, retaining their shape although subjected to a small circular translational motion and to the disintegrating tendency of the outward flow of the liquid.

The centripetal effect described is akin to the well-known phenomenon which occurs when fluid with a few heavy particles is made, by stirring, to rotate in a stationary beaker, with the result that the particles are swept along the bottom to the centre of the vessel. This phenomenon has been related (cf. Prandtl[5]) to a group of 'secondary flow' manifestations which exist in the bends of tubes and rivers owing to boundary-layer effects. The effect produced by the wobble-plate differs, however, from the phenomenon in the beaker in that the plate imparts not only a rotational but also a vertical harmonic and a circular translational motion to the contents of the cells. The vertical motion causes the fluid and the suspended elements to rotate at a much slower rate than the main-shaft, but the corpuscles and aggregates are relatively more affected by the vertical accelerations than the fluid, and, in consequence, they are very rapidly drawn into the centripetal flow at the bottom of the cells. The translation, which is synchronous with the rotation of the main-shaft, is due to the sliding effect of the tilt and the position of the test-plate, which lies in the present design of the 'Centripete' in a plane 0·4 mm. above the centre of the wobble motion. As a result of the combined translation and rotation, the corpuscles and aggregates, before reaching the boundary layer, describe an observable path which closely resembles an epitrochoid.

The distance (r) which separates an element moving along this path from the centre of its rolling circle of translation, and which varies with the position the element occupies in the suspending liquid, increases with the angle of tilt (α) and the distance (d) of the element from the true centre-plane. On the other hand, r decreases when the speed of the main-shaft (n) increases. As long as r is kept small, undue turbulence does not arise and the centripetal effect can develop. If, however, α and d exceed certain limits and n is comparatively small, the increased turbulence of the liquid and the relatively large cycloidal excursions of the corpuscles interfere with the development of the centripetal flow and drift, and only a mixing effect is obtained.

Machines specially designed to produce such effects are at present commercially available. Based on a 'tilting and shaking' apparatus described by Magath[6], they are used for agitating test suspensions and for general mixing operations. In the design of the independently developed 'Centripete', on the other hand, provision has been made both for eliminating excessive turbulence and for creating conditions which permit the development of an effect, hitherto apparently not produced by a wobble mechanism or utilized for precise measuring purposes. The observation that this centripetal effect can be developed in widely differing systems suggests an extension of its application to other titration procedures and to the general study of surface properties of small particles or cells.

I am greatly indebted to Sir Alexander Fleming and Prof. G. Temple for their continued interest and encouragement in this work. It is also a pleasure to acknowledge the help given by Mr. A. Stringer in the development of the 'Centripete'.

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[6] Magath, T. B., *J. Lab. and Clin. Med.*, **18**, 83 (1932).

"RADIOLYMPIA"

THE sixteenth national radio exhibition at Olympia, London, now generally known as "Radiolympia", was opened on September 28 by Mr. Herbert Morrison, Lord President of the Council. The exhibition, which remained open until October 8, was organised by the Radio Industry Council, and served primarily to show the present state of development and manufacture of broadcasting sets and television receivers. The range and variety of receivers now available reflects the advanced and stable position of the television service of the B.B.C., and shows that the industry is ready to meet the demand that will be created in the Midlands when the Sutton Coldfield transmitting station is opened next December. Direct-viewing receivers with cathode-ray tubes ranging in size from nine to fifteen inches in diameter are the most popular type, but several firms displayed models of the projection type giving a larger picture on a flat screen. While, as has been announced officially, the present standards for transmitting black-and-white pictures will remain in Great Britain for several years, an interesting demonstration of transmitting and receiving pictures in colour was given by one firm. The method comprises the use of synchronized, rotating colour filters in both camera and receiver giving fifty pictures per second in the three primary colours successively. Although it may be many years before colour television broadcasting becomes a feasible proposition, it is possible that such a system as that shown would have some application on a closed-circuit network for educational, medical or industrial purposes. A feature of particular interest to the visitor interested in television was the installation in Olympia of a complete television theatre. This structure included a stage 90 ft. by 45 ft., probably the largest television stage in the world; and the theatre was used daily during the exhibition for the provision of the normal B.B.C. television service programme.

Apart from completed sets, many of the stands displayed the multifarious types of components that are necessary in modern radio receivers, and including particularly the various designs of aerial system that are suitable for television reception. One firm has also introduced an extension unit, in the form of a remote viewing screen which may be connected to a television receiver. A large variety of testing and measuring instruments were shown, and some of these, such as Geiger counters, had applications in the general electronics rather than in the radio field.

But beyond all this excellent display of radio equipment, several government departments and the defence Services provided exhibits and demonstrations. The Services showed the types of signals and radar equipment, in both fixed and mobile forms, used for their special military applications; while the Ministry of Supply had an extensive display of some of the recent developments in radio and radar techniques. One of the most popular exhibits was that of the Ministry of Civil Aviation, which comprised a working model of the main runway at London Airport, in which visitors could see and hear a miniature aeroplane being guided into position for landing by the airport controller, who was constantly observing the position of the craft on his radar instruments and instructing the pilot by radio-telephony.

An innovation at the exhibition this year was the stand of the Department of Scientific and Industrial Research, illustrating two examples of its work in the field of fundamental radio research. The first was devoted to equipment developed in the Radio Division of the National Physical Laboratory for measuring and recording by photography the characteristics of the main regions of the ionosphere by which long-distance radio transmission is effected. These photographic records are made automatically every hour at the Radio Research Station, Slough, and at the sub-stations of the Department at Fraserburgh in Scotland, and in the Falkland Islands and Singapore. Nearly fifty similar stations are in operation in other countries, and the results of the observations are exchanged. From these results, predictions of the best frequencies to use for broadcasting and communication are prepared six months in advance and issued to the General Post Office, Cable and Wireless, Ltd., the B.B.C. and other authorities in Britain and overseas. The second exhibit on this stand was a joint effort of the Department of Scientific and Industrial Research and the Meteorological Office, illustrating the manner in which the location of the sources of atmospherics is used as an aid to weather forecasting. There again, the equipment shown—a cathode-ray direction finder—was developed in the National Physical Laboratory, and a network of four direction-finding stations in Great Britain and Northern Ireland is used by the Meteorological Office for making hourly visual observations of the storm conditions prevailing over an area of a radius of some 2,000 km. For the demonstrations at Olympia, the stand was connected to the central controlling station at Dunstable during operational runs, so that the visitors could hear the observations being taken, and then in an adjoining section could see them being plotted on a chart, on which the positions of the actual storm centres prevailing at the time were displayed.

As the responsible authority controlling all forms of telecommunication in Great Britain, the General Post Office had a large and representative stand, giving in many cases working demonstrations of some of its activities. A model of the latest cable-laying and repair ship, and a section of a long-distance telephone cable were shown. In another section a radio coast station was reproduced, and visitors could see how communication with ships is established and distress calls handled. Of more direct interest to most people was a demonstration of the consequences of starting a '999' call on the telephone system. The part played by the Post Office in the extension of the television service from London to Birmingham was illustrated, including a demonstration of relaying a television picture over a short centimetre-wave radio link. Finally, and by no means least important, a section was devoted to demonstrations of the various causes of 'noise' interference with radio and television reception and the manner in which these may be avoided by the fitting of appropriate suppressor units in the electrical circuits at the source.

Altogether, "Radiolympia" provided an excellent demonstration of the enterprise and liveliness of the radio industry in Great Britain, and of the advances which are taking place in the science and practice of radio technique. It is gratifying to observe that many overseas visitors went to the exhibition; some of these no doubt were attracted by the very interesting and well-produced booklet entitled "British Radio for the World" which was produced by the Radio Industry Council and distributed to all parts of the world last July.

RADIATION CHEMISTRY AT THE UNIVERSITY OF NOTRE DAME, INDIANA

ALTHOUGH, as Allsopp[1] has recently indicated, radiation chemistry is in reality an old subject, it has received its major impetus during the Second World War. Problems of the production of atomic energy and atomic power require information on the effects of high-energy radiation on structural materials, coolants, moderators and chemicals and containers used in separation processes, as well as on the chemistry of nuclear recoils produced in the processes of radioactive decay or in processes for the separation of radioactive nuclides. Technological aspects of these problems have been handled primarily in the National Laboratories in the United States (Argonne, Oak Ridge and Brookhaven) and at the Chalk River Atomic Energy Establishment, Canada, and also at Harwell, England.

Significantly, academic institutions have confined their attention to non-secret, 'unclassified' fundamental investigations. Such a group is working with Dr. F. S. Dainton at Cambridge. Groups working in the United States include those at the Massachusetts Institute of Technology and Syracuse University. A group at the University of Notre Dame is a direct outgrowth of the activities of the Plutonium Project. That group has attempted to stimulate research in radiation chemistry in a variety of ways: by symposia, by research and by training of new personnel.

The seriousness with which radiation chemistry is considered in the United States is again emphasized by the announcement that the Radiation Chemistry Project at the University of Notre Dame will henceforth be operated under contract from the Atomic Energy Commission. With the stimulation and support of the Commission, Notre Dame will be the first academic institution to install a Van de Graaff generator exclusively for studies in radiation chemistry and allied fields (for example, radiobiology). This generator will be housed in a new building to be added to the present chemistry building. Included in the new structure will be a radio-cobalt source room. Construction was to begin by October 1, 1949, and it is expected that the entire new installation will be in operation by May 1, 1950.

The staff of the Radiation Chemistry Project includes Prof. Milton Burton (director) and Andrew J. Boyle (administrative director), Associate Prof. William H. Hamill and John L. Magee, and Assistant Prof. Russell R. Williams, jun. Also on the staff are approximately fifteen graduate fellows and technicians. The number of the latter is not fixed, and it is expected that the increased funds available will lead to substantial increases in the staff.

Among the fields at present under investigation are the effects of high-energy radiation on ionic crystals and on organic compounds and solutions, 'hot-atom' chemistry, radiation chemical monitoring, theory of elementary physical processes, chemical behaviour of excited molecules and ions, stability of metastable ions, etc. Only non-secret work will be done under the auspices of the Atomic Energy Commission.

Prof. Burton will continue to direct systematic investigations in the radiation chemistry of organic compounds, ionic solids, and aqueous solutions, and will collaborate with Prof. Magee, who will direct research on theoretical problems. Prof. Hamill will direct work which emphasizes employment of radioisotopes in radiation chemistry, while Prof. Williams will direct studies primarily in 'hot-atom' chemistry and the behaviour of energetic radicals as well as continue work in pedagogic aspects of nuclear chemistry.

An interesting aspect of the work of the Radiation Chemistry Project at Notre Dame is the emphasis which is placed on employment of the mass spectrometer, radioisotopes, and special arrangements of the glow-discharge in the elucidation of elementary processes.

[1] *Brit. J. Radiology*, **22**, 183 (1949).

ELECTRON DEFECT CENTRES IN ALKALI HALIDES

By J. ALEXANDER and Dr. E. E. SCHNEIDER
King's College (University of Durham), Newcastle upon Tyne

THE absorption curves of crystals of sodium and potassium chloride coloured by X-rays obtained by Molnar[1] have shown a rise in absorption towards the ultra-violet edge (2,300 A.) of his spectral range. We have made measurements of this V-band[2] extending down to 2,000 A. which have established that it is an essential feature of all photochemically coloured alkali halide crystals wholly complementary to the F-band in the visible spectrum. The V-band in the chlorides follows very closely the theoretical absorption curve of a single classical oscillator (Fig. 1). In potassium bromide it has two components, the relative intensity of which depends on the intensity of coloration (Fig. 2).

The position of the maximum and the half-width of the absorption (shown in the table) are characteristic of the crystals investigated. The results are independent of the state of purity of the crystals (indicated by the value of k_0) and of the irradiation conditions (for example, crystals of 10 mm. × 5 mm. × 1 mm., 30–120 min. exposure to filtered X-rays from a crystallographic set, 50 kV., 20 m.amp., $\lambda < 0{\cdot}7$ A.).

TABLE SHOWING ABSORPTION FOR DIFFERENT ALKALI-HALIDE CRYSTALS COLOURED BY X-RAYS. k_0 IS THE ABSORPTION CONSTANT BEFORE X-IRRADIATION

Source	k_0 in cm.$^{-1}$	Maximum of the absorption band		Half-width of band in eV.
		in A.	in eV.	
KCl (synthetic)	0·51	2 205	5·60	1·39
NaCl (synthetic)	1·30	2 170	5·70	1·03
NaCl (natural)				
No. 1	3·61	2,170	5·70	1·03
No. 2	3·27	2,180	5·67	1·03
KBr (synthetic)	2·08	2,320	5·32	0·83
		2,580	4·77	0·86

Experiments on the properties of X-ray coloured crystals, chiefly potassium chloride, associated with the V-band have yielded the following results.

Ageing Process. The V-absorption continues to grow after the end of X-ray exposure and, at room temperature, reaches a final steady value only after an ageing period of about twenty hours. The increase

in absorption during this time is the greater the lower the temperature of the crystal during X-irradiation, ranging from 15 per cent for −50° C. to 8 per cent for +20° C. irradiation temperature.

Relation of V- and F-centres. The number of *V*-absorption centres in 'aged' X-ray coloured crystals not previously exposed to visible or ultra-violet light is equal to the number of *F*-centres ($\sim 10^{17}$ cm.$^{-3}$ for 30 min. X-ray exposure). This result is derived from the observed agreement between the products of maximum absorption and half-width of the two absorption bands on the assumption of equal oscillator strengths, an assumption which is reasonable in view of the 'classical' shape of both absorption curves, and of the experimental value $f = 0{\cdot}8$ for *F*-centres in potassium chloride[3,4].

Bleaching by F-irradiation. The quantum efficiency of the bleaching of the *F*-absorption by irradiation in the *F*-band of freshly coloured crystals has an initial value of approximately 1; it decreases rapidly and reaches eventually a value as low as 0·005. In aged crystals the initial rate of bleaching is considerably smaller. The *F*-bleaching is accompanied by the formation of secondary colour centres (*M*-centres[1,2]) and also by a bleaching of the *V*-band. The rate of *V*-bleaching is at first much smaller than that of the *F*-band, but approaches it towards the final very slow phase of the bleaching process.

V-band Bleaching by V-irradiation and Restoration. Irradiation with ultra-violet light corresponding to the maximum of the *V*-band bleaches the *V*-absorption with a quantum efficiency approximately 1 without affecting the *F*-absorption. On cessation of the ultra-violet irradiation, the *V*-absorption returns gradually to its original value. At room temperature this restoration process occupies a period of two to three days.

Fast Bleaching by Combined V- and F-irradiation. Simultaneous or successive irradiation in the *V*- and *F*-bands produces a very fast and complete bleaching of the crystal throughout the whole spectrum. An aged crystal first irradiated in the *V*-band bleaches during subsequent irradiation in the *F*-band at a quantum efficiency of approximately 1; that is, every electron liberated by the *F*-absorption is removed. This rapid bleaching goes on until the number of *F*-centres destroyed is equal to the number of *V*-quanta absorbed previously; after that, the bleaching continues at the very slow rate observed under normal conditions.

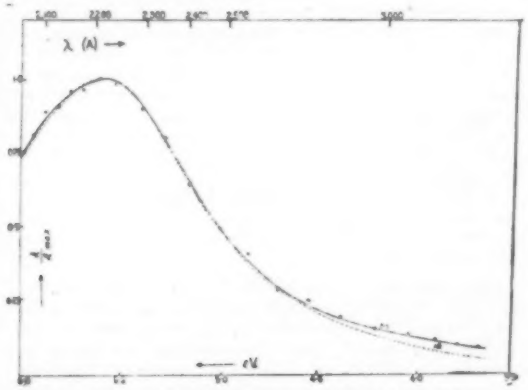

Fig. 1. V-absorption in KCl. Temperature 21·5°C. $k_{max.}$ (absorption constant at the maximum) = 5·76 cm.$^{-1}$. o—o—, Experimental curve; – – – – –, theoretical curve

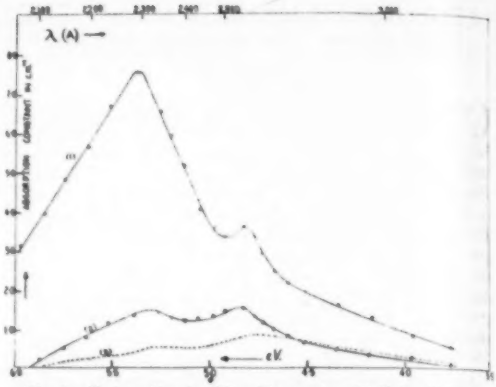

Fig. 2. V-absorption in KBr. Temperature 21·5° C. (1) High concentration of centres; (2) low concentration of centres; (3) (dotted) absorption curve of stoichimetric excess of halogen in KBr crystal (Mollwo)

Isolation of V-centres. *F*-centres can be withdrawn from a coloured crystal if a strong electric field (about 2,000 volt/cm.) is applied during irradiation in the *F*-band. Crystals treated in this way are left with only the *V*-band, which cannot be bleached permanently by light of any wave-length.

It is usually assumed that the essential photochemical action of X-rays (or other ionizing radiation) on alkali halide crystals consists in the dissociation of halogen ions into electrons, forming *F*-centres and halogen atoms. Our experiments find a natural explanation if the *V*-band is associated with the presence of halogen atoms in the crystals, forming positive holes in the normal lattice. This interpretation, which mainly rests on the equality of the *V*- and *F*-centre concentrations, is strongly supported by the agreement between the ultra-violet absorption observed by us in X-ray coloured crystals of potassium bromide and that observed by Mollwo[5] in potassium bromide crystals containing excess bromine (see Fig. 2).

The bleaching experiments can be understood if it is assumed that in the normal *V*-centre state positive holes are bound in traps in the lattice where they are electrically neutralized, and thus have a very small capture cross-section accounting for the normal very slow bleaching of the *F*-band. The fast bleaching of the *F*-band in freshly coloured and *V*-irradiated crystals would have to be explained by the presence of free or untrapped positive holes which readily attract electrons and recombine with them to form halogen ions, and the ageing and restoration processes by a gradual filling or re-filling of the traps. Irradiation in the *V*-band is in this picture assumed to result in the formation of free positive holes. The two peaks of the *V*-band in potassium bromide and in potassium iodide containing excess iodine[6], the energy separation of which agrees with that of the $2P_{1/2}$–$2P_{3/2}$ levels of free halogen atoms, should, therefore, be associated with a splitting of the end state of the absorption process rather than with a fine structure of the initial state, which corresponds to trapped positive holes, and is less likely to resemble the ground state of free halogen atoms.

[1] Molnar, J. P., Ph.D. Thesis, Mass. Inst. Tech., 1940.
[2] Seitz, F., *Rev. Mod. Phys.*, **18**, 384 (1946).
[3] Kleinschrod, F. G., *Ann. Phys.*, **27**, 97 (1936).
[4] Mott, N. F., and Gurney, R. W., "Electronic Processes in Ionic Crystals", 115.
[5] Mollwo, E., *Ann. Phys.*, **29**, 394 (1937).

FRIEDEL–CRAFTS POLYMERIZATION

ON July 5–7, a symposium on Friedel–Crafts polymerization was held in the Chemical Laboratory, Trinity College, Dublin, under the chairmanship of Prof. M. G. Evans. Papers by Drs. F. S. Dainton, M. H. Dilke, D. D. Eley, A. G. Evans, S. D. Hamann, G. W. Meadows, D. C. Pepper, F. T. Perkins, P. H. Plesch and A. W. Richards were presented. The discussion revealed the scarcity of quantitative information in this field, but resulted in appreciable clarification of a number of obscure points. A clear picture of the reaction mechanisms emerged, which should be of value as a guide to future work.

Ionic character of the reactions. This has always been inferred from the fact that olefines containing strongly electrophilic groups cannot be made to polymerize by Friedel–Crafts catalysts, and from the electrophilic character of the catalysts themselves. Also, the low overall activation-energies are characteristic of ionic rather than radical reactions. New evidence on this point has been provided by the observation (A. G. Evans and Hamann) that 1 : 1 diphenyl ethylene in the presence of several Friedel–Crafts catalysts shows the absorption spectrum of diphenyl methyl carbonium ion. The marked effect of the dielectric nature of the solvent on these polymerizations (Pepper) also indicates ionic processes in them. The electrical conductivities of monomer-catalyst solutions are very low or anomalous, so that it seems likely that the free carbonium ions are not present, but rather ion-pairs with the carbonium ion closely associated with a *gegen* anion derived from the catalyst. The large energy of charge separation, even in solutions of fairly high dielectric constant, would seem to rule out any appreciable concentration of free ions.

Initiation process. It has been shown conclusively (Evans and Meadows) that the polymerization of *iso*butene cannot be initiated by boron trifluoride alone, and most probably not by titanium chloride (Plesch) or by stannic chloride (Norrish and Russell). Initiation of *iso*butene can be brought about only by complexes formed from the Friedel–Crafts compounds and certain hydroxylic co-catalysts, for example, water, *t*-butyl alcohol, acetic acid, etc. On the other hand, vinyl ethers (Eley and Richards) and styrene in solvents of high dielectric constant (Pepper) appear to need no co-catalyst. It is concluded that where co-catalysts are necessary, the initiation process must be the transfer of a proton from the catalyst–co-catalyst complex to the monomer, resulting in a carbonium ion–*gegen* anion pair. In such systems the simple polarization of the monomer double-bond by electron donation to the Friedel–Crafts catalyst itself appears to be inadequate for initiation. In systems which do not require an added co-catalyst the above conclusion is not so inevitable, but it seems likely that in these cases also initiation is due to proton (or carbonium ion) transfer from a catalyst–solvent, or even catalyst–monomer complex.

Propagation step. Preliminary kinetic information (Plesch) indicates that the activation energy for propagation of *iso*butene is low (~4 kcal./mol.), as might be expected for an ionic reaction. The propagation process is envisaged as the addition of a monomer or polymer carbonium ion, resulting in a polymer carbonium ion which is one monomer unit longer but still associated with the *gegen* anion derived from the initiating complex.

Termination step. Kinetic investigations of the polymerization of vinyl ethers (Eley and Richards) and of styrene (Pepper) indicate that in both these systems the termination step is unimolecular. Full kinetic information for *iso*butene is not available, but here also a unimolecular termination reaction seems probable. In these systems, therefore, the termination process cannot be the combination of polymer carbonium ion with a free anion, but must be either the spontaneous expulsion of a positive charge, or some kind of 'internal neutralization'. In all systems studied there is evidence that each catalyst molecule (or catalyst-co-catalyst complex) gives rise to many polymer molecules, that is to say, the initiating complex must be regenerated in the termination process. There is also much evidence that the polymers contain a double bond, that is to say, a proton must be expelled from the carbonium ion. Such proton expulsion has been demonstrated spectroscopically (Dainton and Sutherland) in *iso*butene polymerized by boron trifluoride–deuterium oxide complex. The termination step is therefore envisaged as the loss of a proton from the carbonium ion to the *gegen* anion, thus regenerating the initiating complex and leaving a double bond at the end of the polymer molecule. For this combination of ions to be a unimolecular process, the polymer carbonium ion and the complex anion must be one kinetic unit, that is to say, the ions must always be in close association with one another.

Transfer processes. There is no evidence for transfer processes in the polymerization of *iso*butene or of styrene, but transfer to monomer appears to take place in vinyl ethers in that the molecular weight of the polymer is independent of the monomer concentration (Eley and Richards). The relative importance of transfer processes in terminating chains is dependent on the catalyst used, being negligible with stannic chloride but dominant with iodine and silver perchlorate. This observation provides further evidence that the catalyst-complex anion is always in close association with the growing polymer carbonium ion.

Depropagation. Reversal of the propagation process has been demonstrated (Dainton and Ivin) in the co-polymerization of butene and sulphur dioxide catalysed by silver ions and other catalysts. It is suggested (Dainton) that the low molecular weights usually obtained in Friedel–Crafts polymerizations at room temperature might be due largely to this cause. Especially in the polymerization of $\alpha\alpha'$ disubstituted monomers, low 'ceiling temperatures' would be expected as a result of their lower heat of polymerization. Whether depropagation or transfer processes are the operative factors in limiting molecular weight can be decided from the form of the molecular weight–temperature relation. An interesting feature of these ionic polymerizations is that even at the end of the reaction the polymer has a terminal double bond, and catalyst is still present, that is, conditions are established for a mobile polymer $\rightleftarrows$ monomer equilibrium, so that if the temperature is raised depolymerization should ensue. There is some evidence that such mobile equilibrium may be established in *iso*butene–boron trifluoride hydrate systems, but further demonstrations are to be sought.

A clear picture of the main steps in an ionic polymerization has thus emerged. The initiating agent is not the simple Friedel–Crafts compound, but an ionic complex of it with a co-catalyst, solvent or perhaps monomer. Initiation consists in transfer from the complex to the monomer of a proton (or positively charged fragment) forming a carbonium ion which remains in close association with the anionic residue of the complex. The carbonium ion grows by adding monomer to form larger carbonium ions which at each stage maintain this close association. The *gegen* anion must, therefore, be regarded as 'travelling along' the propagating chain as it grows. Termination consists of the spontaneous loss of a proton to the *gegen* anion, leaving a double bond in the polymer and a regenerated initiating complex.

The above theory of the reaction mechanism is in accordance with the available experimental evidence, but is almost certainly over-simplified. There are still many obscurities which await clarification. For example, the initiating complexes of boron trifluoride with water or acetic acid are ionic crystals insoluble in *iso*butene, and in these systems the polymerization reactions are probably heterogeneous. It may be unsafe, therefore, to include these systems and the homogeneous polymerizations of vinyl ethers and styrene in one generalization about reaction mechanisms. In the homogeneous systems, the possible existence of solvent–catalyst complexes, and the details of the effect of dielectric constant, are still unsettled. A serious deficiency in the experimental evidence is that in systems where there is spectroscopic information about end-groups and catalyst fragments in the molecule there are few kinetic data, and vice versa. The relative importance of transfer or depropagation processes as the factors limiting molecular weight still remain to be explored.

D. C. PEPPER

THE HEALTH OF ENGLAND AND WALES

THE report of the Ministry of Health for the year ending March 31, 1948, and the report of the Chief Medical Officer for the year ending December 31, 1947, which are again published together to form a comprehensive survey of the health and health services of England and Wales*, once more record excellent health statistics.

During the period covered by the Ministry of Health's report, the birth-rate (20·5 per thousand of the population) was the highest since 1921; the infant mortality-rate (41·37 per thousand related live births) was the lowest recorded, and may be compared with the rates of 50·57 in 1939 and 153·1 during the years 1871–75; the still-birth-rate was 24·1 per thousand of all births, compared with 38·3 per thousand in 1938; and the maternal mortality-rate was 1·17, which may be compared with the rate of 3·94 for 1938. In 1921 there was also a high birth-rate and a very hot, dry summer, yet the infant mortality-rate was 83. It is evident, therefore, that many children and mothers owe their existence to-day to the careful, painstaking work of all those who administer the maternal and child-care services described in this report.

Deaths from diphtheria were half those recorded in 1946. A table shows the remarkable decline in the number of deaths due to this disease since 1941, and other figures quoted show how much is owed to the policy of immunization followed in Great Britain. The experience of other countries has been very different. During the period reviewed by the report, scarlet fever caused only forty-two deaths, a new low record; deaths from measles reached a new low level; diabetes killed fewer people than it has ever done; and the notifications of dysentery were further reduced. Another low record was the combined death-rate for children under fifteen afflicted with rheumatic fever and heart disease (39 per million). These results were achieved during a period which included an exceptionally severe winter, an exceptional scarcity of fuel, rationing of bread and potatoes, and reductions of the rations of meat and bacon. Probably the hard winter caused the rise reported in the number of deaths of old people and the slight increase in the deaths from tuberculosis. The sections of the report which describe the extensive work on the control of tuberculosis show what excellent work is being done to fight this scourge, and include details of the valuable work of the mass miniature-radiography units, the number of which is being increased.

The other details given by the report provide, on every page, evidence of the devoted work of health workers of every kind. The epidemiology of infectious diseases during 1947 was, on the whole, satisfactory, but the unexpected epidemic of poliomyelitis ('infantile paralysis') reached a figure (18 per hundred thousand) four and a half times higher than that of the heaviest epidemic previously recorded; and 707 deaths occurred. This was the first large-scale epidemic of this disease, which is again causing trouble this year. Possibly many people suffer mild, unrecognized attacks of it, and many carriers exist. Knowledge of it is increasing slowly, but at present we know little of its methods of spreading. The report states that most people seem to have considerable immunity to it and that children, especially those less than five years of age, seem to be becoming less susceptible. Nearly two-thirds of the people who died of this disease during the period covered by this report were more than fifteen years old, so that the term 'poliomyelitis' is preferable to the term 'infantile paralysis'.

The report records a marked fall of new cases of syphilis and gonorrhœa, and suggests that a decline of war-time infections, together with increased public knowledge of the seriousness of these diseases and earlier and more effective treatment of them, may lead to a progressive reduction of their incidence. The crude civilian death-rate from cancer did not change during the period under review.

The work done upon other aspects of national health cannot be adequately described in a short review. The report includes descriptions of the work of the Public Health Laboratory Service upon the Vi-phaging of typhoid and paratyphoid bacilli, the testing and regulation of ice-cream manufacture and investigation of outbreaks of food-poisoning; the national blood-transfusion service, the increased and very valuable work of which has, since the War, received less public notice than it deserves; and the extremely valuable work, always in progress, on diets and nutrition, the efficiency of which is probably the basis of the excellent health of the people. Other

* Report of the Ministry of Health for the Year ended March 31, 1948, including the Report of the Chief Medical Officer on the State of the Public Health for the year ended December 31, 1947. (Cmd. 7734.) Pp. 282. (London: H.M. Stationery Office, 1949.) 5s. net.

sections of the report deal with hospitals, the insurance medical service, mental health, housing, local government, water supplies, sewerage, and that other very important aspect of the Ministry's work, the health control of airports. The system of control that has been established includes the scrutiny of all incoming air passengers, a more detailed medical examination of special cases, the issue of warning cards and the record of passengers' addresses, so that they may be traced if necessary. During the period covered by the report there were only two instances of the entry of major epidemic diseases by air into Great Britain, one being a case of smallpox, the other a suspected case of cholera, and, in each case, every person who had travelled in the aircraft concerned was easily traced and placed under observation.

Many readers of the report will be especially interested in Sir Wilson Jameson's tribute to the high standard of the work of the nurses and midwives. Confronted with a high birth-rate, great shortage of maternity accommodation and shortage of staff, they overcame great difficulties. Sir Wilson considers that the improved vital statistics relating to mothers and infants "reflect much credit on all concerned". He also commends the enlightened food policy, which gives priorities to expectant and nursing mothers, and to infants and children; and he specially acknowledges the help received by the Ministry from voluntary organisations and all those who work for them. Nobody will be able to read this report without gratefully endorsing these tributes and adding his own gratitude to everyone who is in any way associated with this great volume of beneficent work.

G. LAPAGE

CLEARING BIRDS FROM AIRFIELDS

THE need for some form of preventive measures to combat the bird menace to fast-flying aircraft has long been realized both in the United Kingdom and in other parts of the world. Many different methods of driving flocks of birds from airfields have been tried. Shooting, and the use of Verey cartridges and rockets, have met only with momentary success. Scarecrows, dogs and the use of motor-transport to scare the birds away have proved to be useless; the birds speedily accustom themselves to these measures and disregard them.

The number of accidents to aircraft in the past, the expected vulnerability of high-speed aircraft to bird collisions in the future, and the lack of any known preventive measure, led, in the latter part of 1946, to the calling by the Ministry of Supply of an *ad hoc* meeting to consider the problem and to recommend, if possible, effective ways in which this danger could be removed. This conference, consisting of representatives from the Ministry of Supply, the Air Ministry, the British Museum (Natural History) and from various ornithological societies, agreed that information should first be obtained about the numbers of birds involved and their habits*. At the same time it was decided that an investigation should be made into the use of tame falcons for driving the birds away. These two lines of investigation were accordingly initiated in March 1947, under the auspices of the Deputy Directorate of Accident Prevention, Air Ministry, and Scientific Research (Operations), Ministry of Supply. The interest of the Ministry of Supply was taken over by the Ministry of Civil Aviation in September 1947, upon the formation of the latter's Operational Research Section.

Investigations by Mr. R. S. R. Fitter and a team of voluntary observers showed that the birds constituting the greatest danger to aircraft are gulls and members of the crow and plover families, which resort to the runways to digest and preen after feeding on the animal and insect life present in the soil. These birds disregard all aircraft on the ground and in the air, but will fly up and circle about in the path of any aircraft that is taking off or about to land, providing an additional hazard at a time when the pilot needs all his concentration. Other smaller birds, mainly skylarks, are present in fairly large numbers at airfields throughout the year; but the degree of danger is considered to be less than in the case of the species previously mentioned.

The investigations showed that the problem was most acute in the autumn and winter months. Various methods of freeing the airfields from these bird flocks were then considered, and it was finally agreed to experiment with trained falcons. With the help of Mr. R. S. Stevens, a noted amateur falconer and ornithologist, the Air Ministry carried out experiments which, at the end of the first year, were sufficiently encouraging to make it worth while to continue the research and to include the training of some airmen falconers. The experiments were continued until February 1949, and, as a means of driving birds away from airfields, proved a marked success. Falcons speedily and effectively cleared the unwanted birds away wherever they were flown; but the casualty rate among the falcons was high through sickness and shooting, and it was not possible to fly the hawks during periods of really bad weather. Although effective, the high cost of maintaining falcon detachments makes this method impracticable as a regular means of clearing birds from airfields.

The use of supersonics has also been considered and has been based on the knowledge that sounds of a frequency of 20,000–30,000 cycles per second have been used in experiments to clear bird life from reservoirs and public buildings. Small-scale supersonic projectors giving a powerful high-frequency sound with a quavering effect have effectively disturbed all bird life within a radius of a quarter of a mile, and experiments are now in progress to increase the range or volume of these projectors; if these are successful the scope will be extended to include a large airport. It is hoped that the use of supersonic projectors will effectively solve the problem of clearing birds from airfields.

Besides these measures, investigations in the United States have led to the designing of a windshield which will resist the impact of a bird at high speed. It has been found that the point of impact on 28 per cent occasions was the windshield. The results obtained by the Structures Section of the Aircraft Development Divisions, Civil Aeronautics Administration, led to an American Civil Air Regulation that requires new carrier aircraft (that is, civil passenger aircraft operating on scheduled routes) to be fitted with windshields able to withstand the impact of a 4-lb. bird carcase at the cruising speed of the aircraft. This cannot rightly be considered an answer to the menace of birds as it accepts the risk and sets out to minimize rather than remove the danger. The information will, however, be of interest in the designing of new aircraft.

* Experiments in Clearing Birds from Airfields. By F. R. Adams. (Ministry of Civil Aviation.)

LETTERS TO THE EDITORS

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Chemical Reactions Produced by Very High Light Intensities

IT has been a matter of general experience that photochemical reactions are not much altered in their courses by change of light intensity. The range of light intensity hitherto available, however, has been limited by that obtainable from the sun and from such sources as high-pressure mercury vapour lamps, the total usable output of which in the region between 2,000 and 5,000 A. does not exceed 10^{20} quanta/second. There are many cases, particularly those photochemical reactions where free radicals are involved, where it would be desirable to extend investigations to much higher intensities into the region where the concentration of intermediates is comparable with that of the reactants.

The gas-discharge flash-lamp which has been developed recently for photographic purposes seemed to offer great possibilities for experiments of this kind, and we have found that this type of lamp is a very efficient source of light in the photochemically useful region. The flash is produced by the discharge of a large condenser through a tube filled with rare gas, and up to energies of about 100 Joules almost any of the usual types of discharge lamp may be used. By using quartz tubes and large tungsten electrodes, we have worked with energies up to 10,000 Joules/flash in a tube 1 metre long. The duration of this flash was 4 m.sec., and the useful light output in the region of absorption of uranyl oxalate was 10^{24} quanta/second. The output is continuous down to at least 2,000 A. and appears to be fairly evenly distributed, and the output at wave-lengths less than 3,500 A. may be further increased by the addition of a little liquid mercury to the gas filling.

The following figures give the percentage decomposition obtained in a few typical substances with a single flash of 4,000 Joules lasting less than 2 m.sec., the substance being contained in a quartz tube, one metre long, lying parallel to the lamp :

Gas	Pressure (cm.)	% Decomposition
NO_2	4	Nearly 100
CH_3COCH_3	3	15
CH_3COBr	3	15
$CH_3COCOCH_3$	2·5	50
CH_2CO	10	40

The gas volume was 500 c.c. in each case, and mercury had been added to the lamp in the cases of acetone and ketene. In addition, with chlorine at a pressure of 1 cm., the enormous Budde effect of 2 cm. was observed.

Three examples of the different behaviour of well-known photochemical systems under these high light intensities will be given.

Acetone and ketene. Instead of the hydrocarbons and carbon monoxide which are normally produced with these compounds, a complex mixture of substances including hydrogen and a high proportion of carbon was obtained. The carbon appeared in an unusual fine cobweb-like formation which hung across the tube from wall to wall.

Chlorine and carbon tetrachloride. Carbon tetrachloride is usually considered to be the final product of the photochemical reaction of chlorine with methane. At these high light intensities, however, when the partial pressure of atoms and radicals present is relatively high, a mixture of chlorine at 1 cm. pressure and carbon tetrachloride at 2 cm. pressure showed an increase of pressure of about 0·3 cm., and a considerable amount of solid product was formed.

Chlorine and carbon monoxide. This well-known photochemical system exhibits one of the most striking examples of the effect of intensity on the course of a reaction. Illumination in the ordinary way of a mixture of chlorine and carbon monoxide produces phosgene quite rapidly, and the reaction can be taken almost to completion. We find that irradiation by a 4,000-Joule flash, however, produces no detectable pressure change in this mixture, and that if phosgene is added it is rapidly decomposed to chlorine and carbon monoxide. The reaction is quite reversible and can be made to proceed either way at will by changing the intensity of the illumination. That the important primary act is the photochemical decomposition of chlorine in both cases was shown by the very small pressure changes produced when pure phosgene was used.

Two effects seem to play a part in changing the mechanism of photochemical reactions at high intensities. First, since the concentration of the intermediates is comparable with that of the reactants, inter-atomic and inter-radical collisions are as frequent as collisions of these intermediates with more stable molecules. Thus, for example, the reversibility of the phosgene reaction may be explained by the reversibility of the reaction $COCl + Cl_2 = COCl_2 + Cl$ followed by $COCl + Cl = Cl_2 + CO$, in full agreement with the schemes of Bodenstein, and Lehner and Rollefson. Secondly, the process is nearly adiabatic, and very high instantaneous temperatures may be reached, due in part to the exothermic reactions of the labile intermediates with each other and in part to the thermal degradation of the absorbed light energy.

The mechanism of some reactions at high light intensity will be discussed in more detail elsewhere; the above examples serve to show that this type of source, which extends the available upper limit of intensity some 10^4 times, produces photochemical effects of unusual magnitude, and in some cases may alter profoundly the normal course of the reaction.

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An Examination of Praseodymium, Neodymium and Samarium for α-Activity

A PHOTOGRAPHIC method for the detection of extremely weak α-activities has recently been described[1]. The method has now been applied to the examination of elements 59, 60 and 62. The results have some bearing on the question whether an unidentified pleochroic halo of a certain type, found in very old mica, is due to an α-active isotope of element 61 [2].

Ilford *C2* plates of 50 microns thickness were impregnated for 30 min. with solutions of praseodymium acetate (2·3 per cent), neodymium nitrate (0·1 per cent), or samarium nitrate (0·1 and 1 per cent anhydrous salt) at *p*H 7. The plates were kept for $t = 22$, 19, 10 and 9 days, respectively, developed, and a certain area of plate searched for α-tracks in the usual way. Every track observed was measured.

In the neodymium experiment, no tracks running entirely inside the emulsion were found in $n = 1{,}000$

fields of view under the microscope (each covering a volume $v \sim 4 \times 10^{-7}$ c.c. if the upper and lower border zones are deducted), except eighteen thorium stars and two samarium tracks. The half-life $\tau_{1/2}$ is given by[1]

$$\tau_{1/2} = \frac{nvcfAt \ln 2}{N},$$

where c is the concentration of the impregnating solution (gram-atoms/c.c.), A is Avogadro's number, and N is the number of relevant tracks. The 'penetration factor' f gives the ratio of the concentrations in the emulsion after drying and in the impregnating solution. On account of the chemical similarity, the penetration factors in the neodymium and in the 0·1 per cent samarium experiment could be assumed to be equal. In the latter experiment penetration could be measured directly by counting the samarium tracks of 1·13 cm. range in air[3]. Fourteen tracks of this kind were found in 100 fields of view. Using $1{\cdot}0 \times 10^{12}$ as the apparent half-life of samarium (natural isotopic mixture)[3], one has

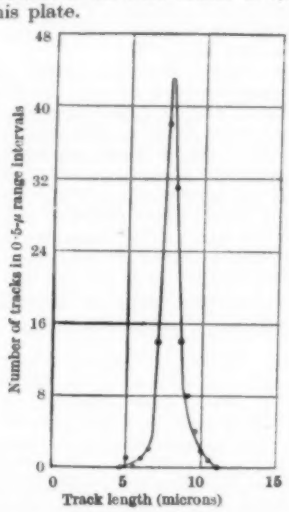
$$\frac{1{\cdot}0 \times 10^{12}}{100 \times (4 \times 10^{-7}) \times (3 \times 10^{-6}) \times f \times (6 \times 10^{23}) \times 10 \times \ln 2} = \frac{}{14 \times 365}$$

Hence $f \sim 10$—a reasonable value for a neutral solution of sufficiently small concentration to make adsorption very effective[1,4]. Therefore, for neodymium

$$\frac{\tau_{1/2} >}{1000 \times (4 \times 10^{-7}) \times (3 \times 10^{-6}) \times 10 \times (6 \times 10^{23}) \times 19 \times \ln 2}{365}$$

$$\sim 2{\cdot}6 \times 10^{14} \text{ years.}$$

In an entirely analogous way a half-life $> 1{\cdot}3 \times 10^{15}$ years is derived for praseodymium; no single tracks at all were found in 1,000 fields of view of this plate.



In the plate impregnated with 'concentrated' solution of samarium, 118 tracks were counted in 400 fields. This leads to a penetration factor $f = 2{\cdot}4$. The spectrum of all tracks observed is given in the accompanying diagram. It much resembles the spectrum given by Cuer and Lattes[13]. The peak would be even sharper if steep tracks, which are hard to measure, were excluded; it is significant that no track of apparent length $> 9\,\mu$ is inclined less than 32°. Clearly, no second group is present. Therefore, the half-life of samarium for an alternative mode of α-decay, or for decay by proton emission[5,6], must be

$$\frac{\tau_{1/2} >}{400 \times (4 \times 10^{-7}) \times (3 \times 10^{-6}) \times 2{\cdot}4 \times (6 \times 10^{23}) \times 9 \times \ln 2}{365}$$

$$\sim 1{\cdot}2 \times 10^{14} \text{ years.}$$

A similar result was reported by Keller and Mather[14], but no spectrum was given.

The unidentified pleochroic halo has a radius of 1·8–2·0 cm. air equivalent[7,8,2], corresponding to about 11·2–12·5 μ of emulsion. It is said to occur only in association with the halo produced by samarium. Now if, in fact, the halo were due to an existing isotope of element 61, the α-ray group should appear in the present plate experiments. Element 61, along with the other rare earths, would be contained in the monazite, from which the neodymium and samarium salts have been prepared. In fractional crystallization it would go partly with neodymium and partly with samarium. In view of the threefold natural abundance of neodymium[9], compared with samarium, probably three-quarters would be found in the neodymium fraction. Comparison of the track counts in the 'dilute' neodymium and samarium experiments (< 1 and 140, respectively, in 1,000 fields) shows, then, that the present activity (defined as the ratio of abundance to half-life) of 61 in rock cannot be more than $\frac{4}{3} \times \frac{1}{1000} \Big/ \frac{1}{3} \times \frac{140}{1000} = \frac{1}{35}$ times that of samarium. Presumably this is insufficient to explain the halo.

Incidentally, consideration of the Gamow equation shows that the assignment of the 1·8-cm. α-radiation to 61 would require β-decay of neodymium, or K-capture in samarium, of the same order of intensity. This fact has been pointed out by Feather (private communication). Admittedly the Gamow equation does not hold well for the 1·13-cm. radiation of samarium. Yet one should obtain at least a very crude idea of the half-life of an α-ray emitter of $Z = 61$ and range 1·8 cm. by using for the nuclear radius the value derived from the application of the Gamow equation to samarium. A half-life of ~ 1 year is calculated in this manner. Consequently, the active species could persist only as long as it is replenished. The only conceivable ways for this to happen are β-decay of neodymium[12] or K-capture in samarium. Because of its small intensity, the required radiation will be hard to find. The radiation reported by Libby[10] as being emitted by neodymium is much too intense.

In view of the absence of an α-radiation in the neodymium fraction, the only remaining possibility of assigning the halo to 61 is through the assumption that the species, or its precursor, has practically died out now. However, there is a general objection to ascribing geochemical effects to decayed species[11]. Qualitatively, the objection is that if a species was still active a considerable time after the origin of nuclei, and has disappeared now, its half-life must be fairly short. In this case, however, its abundance at the start must have been large—which is unlikely for an unstable species. For lack of data on the age of the mica, etc., it is not yet possible to argue this point quantitatively.

It is therefore concluded: (*A*) If praseodymium is α-active, the half-life must be greater than $1{\cdot}3 \times 10^{15}$ years. (*B*) If neodymium is α-active, the half-

life must be greater than $2{\cdot}6 \times 10^{14}$ years. (*C*) If samarium emits a second group of α-rays, the intensity must be at least 100 times less than that of the 1·13-cm. group. (*D*) Any present α-activity of element 61 in rock cannot exceed 3 per cent of the activity of samarium. (*E*) Reasons against assigning the unidentified pleochroic halo of radius 1·8 cm. air-equivalent to element 61 are given. (*F*) If, however, the assignment were true, it would have to be assumed that the species is short-lived and is, or was, replenished from a long-lived source.

Our thanks are due to Prof. K. Przibram for his interest in this work, and to Dr. O. Smetana of Treibacher Chemische Werke for the valuable gift of pure preparations of the rare earths. Moreover, one of us (E. B.) is indebted to Prof. N. Feather for giving the stimulus to this investigation by discussions of the problem of element 61.

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March 31.

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Thickness of the Helium II Film

Determinations of the thickness of the film that covers all solid surfaces in contact with liquid helium II have been made by Daunt and Mendelssohn[1], and by Kikoin and Lasarev[2], by methods which depend on the measurement of the volume of helium II required to form the film on surfaces of known area. The experiments, for which no great accuracy was claimed, gave an average value of $3{\cdot}5 \times 10^{-4}$ cm. for the thickness, and no definite indication of a change of thickness with temperature. Atkins[3] has used a static method involving condensation of helium gas to form the film and bulk liquid, and a dynamic method depending on oscillatory motion of the film. In the latter case, the experiments indicated that the thickness varied inversely as the height above the level of the bulk liquid, the thickness at 1 cm. being about 10×10^{-6} cm.

Theoretical treatments of the helium film have been carried out by Frenkel[5], Schiff[3] and Bijl, de Boer and Michels[6]. The Frenkel–Schiff theory predicts that the film thickness should vary inversely as the cube root of the height. The Bijl, de Boer and Michels theory gives a variation inversely as the square root of the height. The basis of the latter theory has, however, been criticized by Mott[7]. No theoretical treatment of the variation of thickness of the film with temperature has yet been published.

Experiments have been carried out in this Laboratory allowing a direct determination of thickness and its variation with height and temperature. The method depends on the fact that when plane polarized light is reflected from a polished metal surface, it becomes elliptically polarized, the eccentricity and orientation of the ellipse depending on the optical constants of the metal, the angle of incidence and the wave-length of the light. These constants are changed by the superposition of a film of different material, in this case the helium II film, and the measured changes give the thickness of the film, if its refractive index is known. The experimental arrangement is similar to that described by Rothen[8] for the measurement of the thickness of layers of barium stearate. A stainless steel mirror is supported in such a way that the helium film has no further path for creep, and no heat can enter the mirror by conduction (Fig. 1). In later experiments a cylindrical copper radiation shield surrounding the mirror and dipping into the liquid helium was attached to the support below the beaker *B*. The incident and reflected light passed through narrow longitudinal slits in the shield. The temperature of the surroundings of the mirror is maintained uniform to a high degree, and evaporation of the film and of the bulk helium II is very small. The sodium light used for the experiments passes through a total thickness of 12 mm. of Chance's *ON*.19 heat-absorbing glass and has been proved not to evaporate the film to a detectable amount. Under these conditions, the film should be the 'static' one considered in the theories.

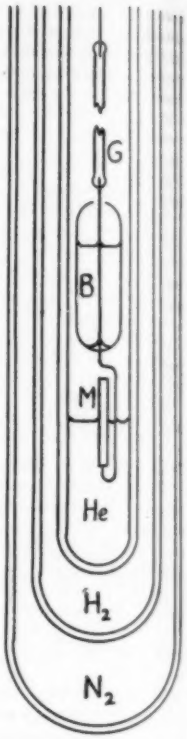

Fig. 1. Cryostat tail. *G*, glass support; *B*, protecting beaker of liquid helium; *M*, mirror

Determinations have been made over the temperature range 1·1° K. – λ-point and for heights varying from 1·5 to 15 mm. The measurements involve settings of a Nicol prism at (i) some known constant temperature below the λ-point (2·186° K.) and (ii) at

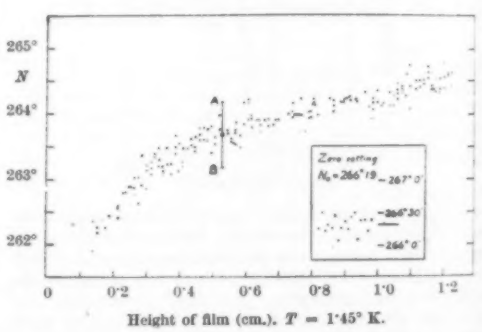

Fig. 2. Relation between Nicol setting and height. *AB*, limits of spread due to movement of observer's eye from extreme left to extreme right at the telescope

some temperature above the λ-point, all other conditions remaining the same, and any film still present in the second case being removed by bringing a small electric lamp near the cryostat. The difference in the readings, which is a measure of the thickness of the helium II film, is throughout approximately 3°, the spread of the individual settings about the mean being ± 10 minutes of arc under good observational conditions. Fig. 2 gives the Nicol readings against height for a typical run at 1·45° K.

There appears to be but little variation of the thickness of the film at a given height with variation of temperature. Under the best conditions of shielding from heat influx the thickness increases from a shallow minimum near 1·6° K. to a maximum at about 2·18° K., and then decreases to zero at the λ-point. This would seem to indicate that the properties of the film cannot be explained in terms of van der Waals' forces only.

The variation of the Nicol rotation with height (h) at any given temperature can be expressed by the equation $\Delta N = k/h^{1/z}$, where z varies from 2·5 at 2·1° K. to about 3·5 at 1·1° K.

A provisional calculation has indicated that the relation between rotation of the Nicol and film thickness is almost linear over the range of thicknesses involved, and that a rotation of 200′ corresponds to a thickness of $2{\cdot}4 \times 10^{-6}$ cm. Thus the thickness at 1 cm. height and 1·5° K. is provisionally given as $1{\cdot}9 \times 10^{-6}$ cm.

We are indebted to Mr. H. Preston-Thomas for general assistance throughout the investigation, especially in the control of the temperatures.

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May 17.

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Photo-Fission of Uranium with Possible Emission of a Beryllium Nucleus

In the study of the slow-neutron ternary fission of uranium-235, there is evidence that short-range particles of greater mass than α-particles are emitted. Dewan and Allen[1] have reported ionization chamber experiments indicating the emission of particles of mass 13 ± 4 having ranges less than 1 cm. of air, and Titterton[2] has recorded events in photographic plates which suggest the emission of nuclei heavier than α-particles having ranges up to 3 cm. air equivalent. An example of such an event is given in Fig. 1, from which it will be seen that, owing to the short range of the third fragment, certain interpretation cannot be made.

The presence of energetic heavy fragments in the ternary photo-fission of uranium has now been suggested by the disintegration shown in Fig. 2, which was observed in a uranium-loaded Ilford emulsion type D_1 irradiated with 23 MeV. gamma-rays from the synchrotron of the Atomic Energy Research Establishment. Superficially, the disintegration appears to be a quaternary fission with the emission of two α-particles of energies 9·5 and 10·5 MeV. respectively, and inclined at 7° to each other. A second possibility is, however, that the event represents the emission of a beryllium-8 nucleus with an energy of 20·0 ± 0·5 MeV., which immediately disintegrates into two α-particles, the angle of emission of the beryllium-8 nucleus relative to the light fission fragment being 74°. This hypothesis can be tested by estimating the energy release, Q, required in the disintegration of beryllium-8 to give the observed energies, E_1 and E_2, and the angular separation, θ, of the α-particles. Q is given by the relation :

$$2Q = E_1 + E_2 - 2(E_1E_2)^{1/2} \cos \theta,$$

which gives, using the observed values, $Q = 85 \pm 25$ keV. This value is in reasonable agreement with the figure 103 ± 10 keV. given by Hemmendinger[3] for the energy released in a transition from the ground-state of beryllium-8 to two α-particles.

Only one event of this kind has been observed in a study of some 10,000 photo-fissions, although many events involving the emission of single α-particles have been recorded[4].

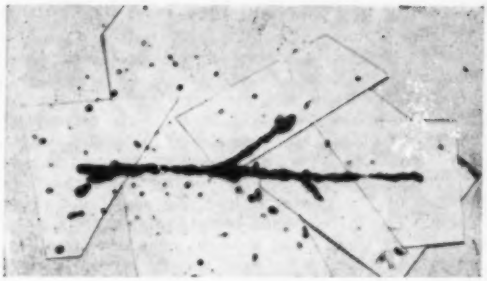

Fig. 1. Slow neutron ternary fission with possible emission of a short-range heavy fragment having M greater than 4. Observer : E. W. Titterton

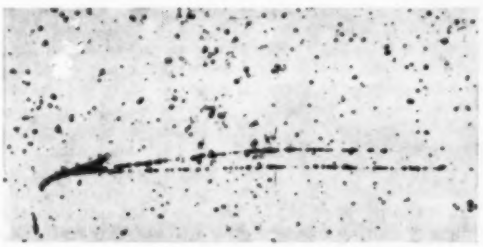

Fig. 2. Photo-fission with probable emission of a beryllium-8 nucleus. Observer : Mrs. A. M. Brown

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E. W. Titterton
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Harwell, Berks.
Aug. 19.

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Scattering of Polarized Neutrons by Protons

In spite of many attempts, it has not been possible so far to develop a theory of nuclear forces which accounts in a satisfactory way for all the properties of even the simplest system, a neutron and a proton. An alternative procedure might, therefore, be attempted, namely, to obtain the interaction potential empirically from the various observed properties like the binding energy, quadrupole moment, magnetic moment of the deuteron and the scattering cross-section. The latter seems particularly useful for this purpose, as there exist general reciprocal quantum mechanical relations between the differential scattering cross-section $d\sigma$ and the interaction potential; $d\sigma$ is expressed in terms of certain phase shifts η_l, ($l = 0, 1, 2, \ldots$), suffered by the partial waves of different orbital angular momentum l due to the interaction between the two particles. For spinless particles, a knowledge of $d\sigma$ (as a function of the angle of scattering θ) determines all the phase shifts η_l and *vice versa*, and a knowledge of the phase shift η_l (as a function of energy) for a given l-state determines the interaction potential for that l-state and *vice versa*. However, the fact that the neutron–proton system splits into the singlet and triplet states (with different interactions) makes the determination of the phase-shifts from a knowledge of $d\sigma(\theta)$ alone impossible.

It is the purpose of this note to point out that this difficulty can be overcome by utilizing an additional property, namely, the partial depolarization of a polarized beam of neutrons on scattering by an unpolarized proton gas. This partial depolarization is due to the spin dependence of the interaction potential; for example, if the triplet interaction were zero, then the scattered neutrons would be completely depolarized. The result of depolarization measurements can be expressed in terms of a depolarization factor P, defined as the difference between the absolute probabilities that the spins of scattered neutrons point parallel or antiparallel to the spin direction of the incident neutrons.

Now if the interaction potential were spherically symmetrical then it can be shown that from a knowledge of the angular distribution of scattering cross-section and of P, all the phase-shifts both for triplet and singlet states could be uniquely determined and thus the interaction potentials themselves could be obtained. From the existence of the quadrupole moment of the deuteron, it is known, however, that the neutron–proton interaction is not spherically symmetrical; usually one assumes the interaction potential as a sum of a spherically symmetrical term and a non-central term (which is a function of the angles which the spin directions of the two particles make with the line joining them), the latter being often denoted as tensor interaction. In the presence of the latter, the above analysis for utilizing the experimental observations to determine the phase-shifts and the interaction potential will become more involved than in the previous case. On the other hand, a qualitatively new feature appears in an *azimuthal* dependence of the depolarization P, provided the spin direction of the incident neutrons makes a finite angle α with the incident direction; the azimuthal dependence being greatest when $\alpha = \pi/2$. It is possible to give the expected order of magnitude of the azimuthal variation of P by making use of an interaction potential which gives the correct quadrupole moment and binding energy of the deuteron; for the case $\alpha = \pi/2$, and at $\theta = \pi/2$, the maximum azimuthal variation in P, namely, $P_{\varphi=0} - P_{\varphi=\pi/2}$ ($\varphi = 0$ gives the plane containing the directions of motion and of spin of incident neutrons), is about $\frac{1}{4}$ per cent and 40 per cent for incident neutrons of energies 1 MeV. and 100 MeV. respectively. It thus follows that detection of the azimuthal dependence of the depolarization should permit a determination of details of the non-central interaction between a neutron and a proton.

My thanks are due to Prof. H. Fröhlich for his encouragement during the progress of this work.

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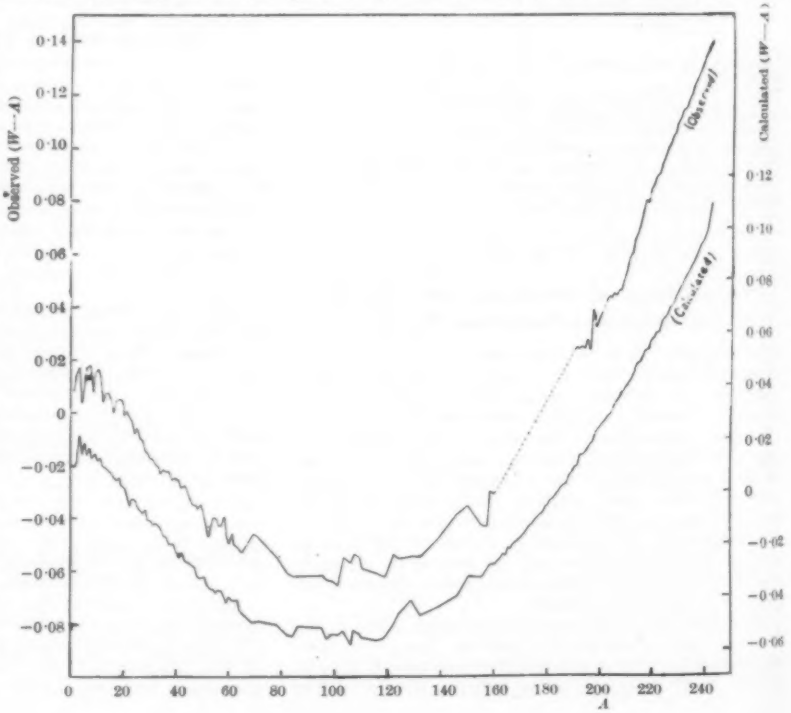
Mass-Defect Curves

In the accompanying graph, giving $(W - A)$ plotted against A, where W is the atomic weight and



A the mass number, two curves, marked 'observed' and 'calculated', are shown, and the latter is discussed in the letter below. The 'observed' curve is based on the empirical data given by Rosenfeld at the end of his book on "Nuclear Forces". The points corresponding to stable nuclei have been joined together by straight lines, and other points have been omitted. There is a gap in the data from $A = 160$ to $A = 190$, indicated by the dotted line.

The periodicity of 4, for the lighter nuclei, is brought out very clearly in the graph. This is especially apparent for $A < 24$. The heavy naturally radioactive group has been included.

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From theoretical considerations, the average binding energy per nucleon can be put in the form[1]

$$\varepsilon = -\varepsilon_1\left[1-\gamma\left(\frac{A-2Z}{A}\right)^2\right] + 4\pi r_0^2 \sigma A^{-1/3} + \frac{3}{5}\frac{e^2}{r_0}Z^2A^{-4/3}. \quad (1)$$

Numerical values of the parameters ε_1, γ, σ and r_0 have been estimated empirically by Mattauch and Flugge[2]:

$$\varepsilon_1 = 14{\cdot}66 \text{ MeV.}, \quad \gamma = 1{\cdot}40$$
$$4\pi r_0^2\sigma = 15{\cdot}4 \text{ MeV.}, \quad r_0 = 1{\cdot}42\times10^{-13} \text{ cm.} \quad (2)$$

Since for a nucleus containing N neutrons and Z protons the average binding energy takes the form

$$\varepsilon = \frac{W - Zm_p - Nm_n}{A}, \quad (3)$$

where m_p and m_n are the atomic weights of a proton and neutron, it is possible to calculate $(W - A)$ from (1), (2) and (3) and to compare the results with the experimental data.

In the preceding note, Prof. Mosharrafa's 'observed' curve is drawn just above the 'calculated' curve for comparison (the two curves are drawn with the same abscissa but with a difference in ordinates of 0·03 mass units).

Although the curve based on the calculated values is of the right shape, the following points are to be observed: (*a*) the periodicity of four which is clearly brought out for $A < 24$ in the empirical curve is not shown; and (*b*) the calculated curve rises less steeply than the empirical one at the end, giving lower values for $(W - A)$.

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Inelastic Scattering of Deuterons

We have recently performed experiments which show that deuterons are scattered inelastically by aluminium and magnesium targets. Such inelastic scattering is well known for protons, but has not hitherto been observed with deuterons.

The apparatus used in these experiments was substantially that described by Rhoderick[1]. The maximum energy of the deuterons available from the cyclotron was 6·7 MeV., and this could be reduced to less than 5 MeV. by placing aluminium foils in the scattering chamber in the path of the incident beam.

In general, the energy spectrum of the particles scattered at a given angle is complex. There are many groups of singly charged particles with ranges both longer and shorter than the range of the elastically scattered deuterons. Most of these are presumably to be attributed to protons formed in (d,p) reactions. In addition, at small ranges there are doubly charged particles which we believe to be alpha-particles formed in (d,α) reactions. As yet, we have not analysed all these groups in detail.

However, with both targets, but particularly with magnesium, certain groups are prominent because of their greater intensities. It is these which we believe to consist of deuterons which have suffered inelastic collisions.

If we calculate the Q value (that is, the excitation energy of the target nucleus) for one of these groups, on the assumption that it consists of deuterons, we obtain a value in very good agreement with that deduced from the inelastic scattering of protons. This is shown in the accompanying table.

	Excitation energy of nucleus (MeV.)	
	Proton scattering	Deuteron scattering
Al^{27}	0·88	0·85
	2·15	2·13
$Mg(?\ Mg^{24})$	1·36	1·36

The values we have given for proton scattering are those given by Rhoderick, the 0·88 MeV. in aluminium being the average of his 0·97 and 0·80 MeV. In general, these agree reasonably well with those of other workers. But we regard them as the most satisfactory for comparison with the deuteron figures, since they were obtained with the same apparatus, and many systematic errors will therefore be common to the two sets of data.

Since the particles concerned are singly charged, it is extremely probable either that the above interpretation is correct *or* that they are protons formed in (d,p) reactions. In the latter case the agreement shown in the above table would be fortuitous. However, it is possible to decide between these two hypotheses by a detailed study of the variation of energy (range) of the scattered particles with the energy of the incident deuterons and the angle of scattering. This variation will be different for deuterons and protons formed in (d,d) and (d,p) reactions respectively.

We have made the necessary measurements for the groups corresponding to the 0·88 MeV. level in aluminium and the 1·36 MeV. level in magnesium. In both cases our results agree with the groups of particles being deuterons and disagree with them being protons.

We quote as an example some of the results obtained with magnesium. Measurements were made at seven values of the energy of the incident deuterons. These energies lie between 4·96 MeV. and 6·65 MeV. The Q values calculated, assuming the particles to be deuterons, are scattered about a mean value of 1·36 MeV. with a standard deviation of 0·04 MeV. The extreme values are 1·30 and 1·42 MeV., so that the extreme variation from the mean is only 1·5 × (standard deviation). On the other hand, if we

assume the particles to be protons, the Q values increase systematically as the incident energy is increased from $2{\cdot}29 \pm 0{\cdot}03$ to $2{\cdot}58 \pm 0{\cdot}03$ MeV. (These figures are calculated on the assumption that the reaction takes place with magnesium-24. Although the detailed figures are altered, the argument is not appreciably affected if one assumes magnesium-25 or -26 to be the reacting isotope.)

We have also attempted to show that these groups of particles consist of deuterons by exposing Ilford *E*.1 plates and counting the grains in the tracks. With particle groups which are homogeneous, in the sense of consisting entirely of protons or deuterons, we find that the average number of grains in the last 50 μ of track is about 10 per cent greater for deuterons than for protons. However, in the conditions of our experiments, the particle groups are not homogeneous, the inelastically scattered deuterons being superimposed on a proton background. Consequently, in finding the average number of grains in the last 50 μ of track for tracks of a given length, the average will lie between the proton average and the deuteron average. Since the proton and deuteron averages themselves only differ by 10 per cent, such an analysis is not conclusive. Our results indicate, however, better agreement with the hypothesis that the groups concerned consist of deuterons superimposed on a proton background rather than protons alone.

We conclude, therefore, that the groups corresponding to excitations of 0·88 MeV. in aluminium and 1·36 MeV. in magnesium are deuterons. In view of the agreement in the table of results, it also seems reasonable to attribute the group corresponding to the 2·15 MeV. level in aluminium to deuterons. Our present experiments do not exclude the possibility that the 1·82 MeV. level in magnesium observed by Rhoderick[1] and others is excited by deuteron bombardment. But as yet we have not been able to ascribe a particle group uniquely to the reaction.

The cross-sections for these reactions seem to be very much the same as those for the corresponding proton reactions. In particular, the magnesium cross-section is about five times those for aluminium, and is approximately equal to the cross-section for elastic scattering from magnesium at a scattering angle of 110°.

We do not wish to discuss here in any detail the mechanism of the inelastic scattering of deuterons. In considering the inelastic scattering of protons, it has generally been assumed that the proton enters the nucleus with the formation of a compound nucleus, although other mechanisms involving long-range interactions have been considered[2,3]. But with deuteron bombardment the excitation energy of the compound nucleus would be about 20 MeV., and it is not easy to see how the emission of a deuteron could compete favourably with the emission of a proton or a neutron.

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Rate of Growth of Mercury Drops Forming at the End of a Capillary

Suppose that the size of a spherical drop at any time during its growth is linearly related to a power of the time, and that the initial radius may be considered zero. Then, at time t, its radius is kt^n, its area is $4\pi k^2 t^{2n}$, and its volume is $\frac{4}{3}\pi k^3 t^{3n}$. The exponent n will be $\frac{1}{3}$ if the volume is proportional to t, and $\frac{1}{2}$ if the area is proportional to t.

If drops that would normally break off after time t_1 are caused to break off after t_2, where $t_1 = at_2$, then the ratio of the volume of the larger drop to that of the smaller is a^{3n}. Also, the ratio of the volume of b large drops to that of ab small drops is a^{3n-1}, but the total times are the same in the two cases. Hence, a measurement of the volumes of mercury collected can be used to calculate the exponent n. Thus, if the ratio of the volumes collected in a given time, or, what amounts to the same thing, the ratio of the average rates of flow in mgm. per sec., is c, then $c = a^{3n-1}$, and $n = \frac{1}{3} + \frac{1}{3}\log c/\log a$. For n to be $\frac{1}{3}$ c must be 1, and for n to be $\frac{1}{2}$, c must be $a^{1/2}$.

With a constant head of 60 cm. of mercury, drops were allowed to form at the end of a capillary immersed in 0·1 N potassium chloride at 23° C., and the drop-time and rate of flow were measured in the usual manner. The capillary was then flicked about 90 times per min. by a piece of rubber attached to a glass rod revolving horizontally, thus causing the drops to break off after about one-third of their normal life-time. The rate of flow was again measured. The results were as follows:

Conditions	No. of drops	Time (sec.)	Drop-time (sec.)	Weight (gm.)	Drop-wt. W (mgm.)	Rate of flow m (mgm. per sec.)
Free	47	897·5	19·09	1·3978	29·75	1·558
,,	248	4736·7	19·10	7·3721	29·73	1·556
Constrained	144	892·2	6·2	1·3783	9·6	1·545
,,	145	896·2	6·2	1·3843	9·6	1·545

The ratio c is 1·557/1·545 or 1·008, so n is approximately $\frac{1}{3}$, indicating that the volume of a drop is closely proportional to the age. With drops freely forming in air the drop-time was 45·8 sec., and the rate of flow 1·561 mgm. per sec.

The tip of the capillary was then immersed just under the surface of a known weight of mercury in a beaker, so that the delivery would be continuous instead of in discrete drops. The value for rate of flow was then 1·579 mgm. per sec. To compare the results for dropping in potassium chloride with those for continuous delivery the former results must be recalculated to the same effective head of mercury P. In a solution the back pressure is approximately $3{\cdot}1/W^{1/3}$ cm. of mercury (cf. ref. 1). This gives 1 cm. for the free dropping and 1·5 cm. for the enforced dropping. Since $P = k'm$, then the values of m for $P = 60$ cm. are respectively $1{\cdot}557 \times 60/59$ (= 1·583) and $1{\cdot}545 \times 60/58{\cdot}5$ (= 1·584). With these corrections, therefore, the ratio c becomes almost exactly 1, and the values of m for free and enforced dropping in potassium chloride and continuous delivery become nearly identical.

These results show that the volume of a drop forming under various conditions is simply equivalent to the volume that would flow through the capillary in the same time under conditions of steady flow, and, since the mercury drop is known to be spherical[3], they cannot be reconciled with the hypothesis, based on Knudsen's experiments[3], that the surface area of

a drop increases linearly with time. Actually the area is proportional to the two-thirds power of the time.

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An Infra-Red Band System of SrO

The infra-red band spectrum of strontium oxide has been investigated with the 21-ft. grating at this Institute. The dispersion in the region in question is about 1·0 A./mm. The preliminary results of the vibrational and rotational analyses are given below.

Heads belonging to the infra-red spectrum of SrO have previously been measured by Meggers[1] and Mahla[2]. The former made no analysis; the latter made both vibrational and rotational analyses of a $^1\Sigma$—$^1\Sigma$ transition. His vibrational analysis is, however, not convincing; on the other hand, his rotational analysis seems at first sight to be correct.

We have arranged some of the infra-red bands, forming a $^1\Sigma$—$^1\Sigma$ transition in the following way. The wave-numbers are given, with the wave-lengths in brackets.

v' \ v'' →	0		1		2	3
2	12106·42 (8257·82)	644·92	11461·5 (8722·5)			
	615·35					
1	11491·07 (8700·02)					9578·6 (10437·1)
	619·54					
0	10871·53 (9195·82)	645·35	10226·18 (9776·15)	637·58	9588·6 (10426·2)	

The equation for the band heads is as follows:

$$\nu_h = 10885{\cdot}5 + 623{\cdot}8\,(v' + \tfrac{1}{2}) - 2{\cdot}1\,(v' + \tfrac{1}{2})^2 - 652{\cdot}7\,(v'' + \tfrac{1}{2}) + 3{\cdot}8\,(v'' + \tfrac{1}{2})^2.$$

The vibrational frequency 652·7 cm.$^{-1}$ for the lower state agrees very well with that for the lower state of the blue SrO bands, which were treated by Mecke and Guillery[3] and Mahanti[4]. From measurements of the heads of the bands, Mecke and Guillery obtained $\omega'' = 648$ cm.$^{-1}$, Mahanti 653·47 cm.$^{-1}$.

Mahla made a rotational analysis of the bands at 8258 and 8700 A., and he considered them to be 0,2 and 0,3 transitions respectively. There are some perturbations in the bands. Mahla thought that the lower levels are perturbed. He assumed that the occurrence of these perturbations confirmed the correctness of his rotational analysis. It is, however, possible to alter the J-numbering. We consider that the bands represent the 2,0 and 1,0 transitions, and that some of the upper rotational levels are perturbed, not the lower ones. Our interpretation only requires that the J-numbering of the R-branch be decreased and the J-numbering of the P-branch increased by one unit.

Further, we have made rotational analyses of the bands at 9196 and 9776 A. The analyses show that the former band has the same lower state as the bands at 8258 and 8700 A., and that the bands at 9196 and 9776 A. have their upper state in common. The 9196-band represents the 0,0 transition, the 9776-band the 0,1 transition. Thus, our rotational analysis shows that our arrangement of the bands is quite correct. The analysis of the two last-mentioned bands was very difficult as the upper rotational levels were unusually strongly perturbed. The preliminary band constants are as follows:

$B'_0 = 0{\cdot}303$ $\quad B''_0 = 0{\cdot}336_0$
$B'_1 = 0{\cdot}302_0$ $\quad B''_1 = 0{\cdot}334_1$
$B'_2 = 0{\cdot}302_1$
$r'_e = 2{\cdot}02$A. $\quad r''_e = 1{\cdot}92$A.

Especially below about 8000 A. there are a lot of band-heads in the spectrum indicating several band-systems. A more detailed paper on this investigation will appear in *Arkiv för Fysik*. In a later paper we will return to the blue bands, and the remaining infra-red ones.

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Red Bands of MgO

Magnesium oxide has two well-known singlet systems, a green one and a red one. Vibrational analyses were made by Mahanti in 1932 [1]. Rotational analysis of the red bands was carried out by Mahanti in 1935 [2], of the green bands by one of us in 1943 [3]. Measurements of the heads of the bands show that the vibrational constants for the upper levels are almost equal. Thus it seems likely that the systems have the same upper level; the rotational analysis gave, however, different values of B for the upper levels. It seemed, therefore, of interest to repeat the rotational analysis of the red bands. The preliminary results are given here.

Mahanti stated that the red system is a $^1\Sigma - {}^1\Sigma$ transition. Our plates, however, show distinctly the presence of a Q-branch. The rotational analysis shows that the red and green bands have a common upper level. Thus Mahanti's analysis is incorrect.

The band constants calculated by us for the red bands are as follows (rotational analyses made of the 2,0, 1,0, 0,0, 0,1 and 0,2 bands):

$B_2' = 0{\cdot}570_8$ cm.$^{-1}$ $\quad B_2'' = 0{\cdot}493_9$ cm.$^{-1}$
$B_1' = 0{\cdot}575_4$ $\quad B_1'' = 0{\cdot}498_4$
$B_0' = 0{\cdot}579_9$ $\quad B_0'' = 0{\cdot}503_4$
$r_e' = 1{\cdot}737 \times 10^{-8}$ cm. $\quad r_e'' = 1{\cdot}864 \times 10^{-8}$ cm.
$D' = 1{\cdot}14 \times 10^{-6}$ cm.$^{-1}$ $\quad D'' = 1{\cdot}18 \times 10^{-6}$ cm.$^{-1}$.

The rotational analysis of the green bands (Lagerqvist[3]) was only made of the 0,0 and 1,1 bands. The heads are formed by about twenty P-lines. After the turn of the P-branch at the head the J-numbering of the P-lines ought to be altered by one unit; in the 0,0 band the first resolved P-line after the head is $P(78)$ not $P(79)$, in the 1,1 band $P(73)$ instead of $P(74)$. The rotational analysis of the green bands,

representing a $^1\Sigma - {}^1\Sigma$ transition, gave $B_1' = 0{\cdot}5747$ and $B_0' = 0{\cdot}5797$ cm.$^{-1}$. The agreement is good.

Our analysis shows that the red system represents a $^1\Sigma - {}^1\Pi$ transition. A more detailed paper on the red bands will appear in *Arkiv för Fysik*.

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Revival of Spermatozoa after Vitrification and Dehydration at Low Temperatures

THE effect on spermatozoa of vitrification at temperatures of −79° C. and below has been studied by several authors. Human spermatozoa appear to be the most resistant; a substantial proportion may show good motility on thawing after even prolonged vitrification. Revival is far better when semen is frozen in bulk than when minimal amounts in capillary tubes are used[1]. No explanation of this result is yet forthcoming, but it would appear that rapidity of freezing is less important than the avoidance of surface effects.

Positive results have also been obtained with frog and fowl spermatozoa[2,3], though in both these cases partial dehydration by the addition of sugar solutions was found to be necessary before any significant number of spermatozoa could be revived on thawing. Fowl spermatozoa thus treated showed some slight fertilizing power, but no live chicks were produced[4]. In our experience, revival of fowl spermatozoa after vitrification is negligible when the technique of addition of lævulose is followed.

The object of the present communication is to report the action of glycerol and related compounds, to which our attention was directed by a chance observation, in protecting spermatozoa against the effects of low temperatures. Experiments with human spermatozoa showed that diluents containing glycerol much increased the proportion of spermatozoa that could be revived after vitrification. With this material, the optimal final concentration was about 5 per cent (equal parts of semen and 10 per cent glycerol in Baker's fluid); lower concentrations were less effective, higher ones were immobilizing. Glycerol diluents did little to prolong the survival of spermatozoa thawed out after vitrification, which is usually inferior to that in control specimens. Experiments with propylene glycol and ethylene glycol gave similar results.

Results of a different order were obtained with rabbit spermatozoa. With this species no spermatozoa revive after bulk vitrification of semen. Glycerol diluents were found to be highly toxic, the maximum tolerated concentration being about 5 per cent. With this concentration there was some revival after vitrification (restricted movement of a considerable number of spermatozoa) but no effect, under the conditions employed, such as could be obtained with human spermatozoa.

Dramatic results were obtained with fowl spermatozoa. If fowl semen is diluted with equal parts of Ringer's solution and vitrified at −79° C. for 20 min., and then rapidly thawed, no significant revival of spermatozoa is observed. On the other hand, if the dilution is carried out with Ringer's solution containing 40 per cent glycerol, the spermatozoa resume full motility on thawing. So far as retention of motility is concerned, the specimen is indistinguishable from its unvitrified control; it shows even the wave motion characteristic of fowl semen. Decreasing the final concentration of glycerol below 10 per cent decreases the protection against vitrification. Increasing it above 20 per cent results in progressive immobilization of the spermatozoa, which cannot altogether be reversed by further dilution with Ringer's solution; but with these higher concentrations, no additional loss of motility is caused by vitrification. Specimens of spermatozoa have been found to resume motility completely after long periods (up to ten weeks) of vitrification. Other experiments showed that both propylene glycol and ethylene glycol were more toxic than glycerol, and in relation to their toxicity less protective against vitrification.

The fact that spermatozoa resumed full motility after vitrification under the conditions described above made it possible to investigate the effects of freeze-drying. 1 c.c. of fowl semen was diluted with 1 c.c. of 20 per cent glycerol in Ringer's solution, and vitrified as a thin layer in a 100-c.c. distilling flask at −79° C. The temperature was then allowed to rise to −25° C. and the flask connected to a high-vacuum distillation system of which the condenser unit contained liquid air. After 3 hr., when the distillation was stopped, the semen had the appearance of being dry, and 1·7 c.c. of water was thawed from the condenser. While still cold, the dehydrated semen was reconstituted with 1·8 c.c. of water and warmed to 40° C. On microscopical examination with a 4-mm. objective, active spermatozoa were seen in each field. Further experiments on these lines showed that recovery was better when 30 per cent glycerol in Ringer's solution was used, that the whole of the glycerol remained with the dehydrated semen, from which about 90 per cent of the water was removed by the distillation, and that spermatozoa could not be revived if the preparation was left at room temperature for 2 hr., presumably because of the toxic effect of concentrated glycerol. In each of eight consecutive experiments, motile spermatozoa were observed in the reconstituted semen, the best recovery being about 50 per cent of motile spermatozoa. No information is yet available as to the fertilizing power of spermatozoa thus resuscitated.

These experiments suggest that a high proportion of the water can be withdrawn from fowl semen at low temperatures without killing all the spermatozoa. To what extent this result depends on the retention of glycerol or on the unequal distribution of residual water is not yet clear. Certain obvious experiments on the factors involved and with the spermatozoa of other species are in progress.

We are most indebted to our colleague, Dr. D. F. Elliot, for his vital assistance at several stages of this research. Our thanks are also due to Prof. L. Harvey for the hospitality of his laboratory in University College, Exeter.

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Ribosenucleic Acid in Snake Erythrocyte Nuclei

In a recent paper[1], I described the isolation of nuclei of erythrocytes from the blood of some Brazilian snakes and reported their content in desoxyribosenucleic acid and other constituents. Hammarsten[2] found that the nuclei of the erythrocyte of the hen contain a small percentage (values not reported) of ribosenucleic acid. Therefore it seemed to be of interest to know whether ribosenucleic acid is also present in the nuclei of the blood of snakes.

The erythrocyte nuclei were obtained by the method previously described[1], and the nucleic acids were separated according to the method of Schmidt and Thannhauser[3]. Desoxyribosenucleic acid was determined using the well-known diphenylamine colour reaction of Dische and the phloroglucinol reaction recently proposed by von Euler and Hahn[4]. The filtrate, after the precipitation of desoxyribosenucleic acid, was used for the determination of the ribosenucleic acid by means of the orcinol reagent of Mejbaum[5], and the colour measured in a Beckmann quartz spectrophotometer at 620 mμ. The average values expressed in mgm. per cent of dry weight of nuclei are shown in the accompanying table.

Name of the snake	Number of samples	Desoxyribosenucleic acid		Ribosenucleic acid
		Phloroglucinol reaction	Dische's reaction	
Crotalus terrificus	2	48	52	0·5
Bothrops jararacussu	1	37	38	0·6
Xenodon merrimi	3	38	41	0·7

The statement of von Euler and Hahn that the phloroglucinol reaction is more suitable for the determination of desoxyribosenucleic acid was confirmed, since no colour was obtained in the filtrate free from it, whereas the Dische reaction always produces a slight but visible colour. Consequently, the values obtained with the phloroglucinol reaction should be considered as representing the real ones rather than those determined by the Dische reaction. As shown in the table, the nuclei of the erythrocytes of all the snakes examined contained ribosenucleic acid in a small amount not exceeding 0·7 mgm. per cent.

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Isolation of *Nitrosomonas* from Rothamsted Soil

Since *Nitrosomonas*, a bacterium which oxidizes ammonia to nitrite, was discovered by Warington[1] and the Franklands[2] and first isolated by Winogradsky[3], nearly sixty years ago, there are only a few records of its isolation in pure culture.

Boullanger and Massol[4] obtained *Nitrosomonas* from a sewage filter bed, and Bonazzi[5], Gibbs[6], Nelson[7] and Hanks and Weintraub[8] isolated it from North American soils. Rubentschik[9] isolated a halophilic variant from a salt lagoon near Odessa. Kingma Boltjes[10] obtained pure cultures from soil in the Netherlands, Engel and Skallau[11] and Bömeke[12] from German soil, and Tchan[13] in France. There is no record of its isolation in the British Isles since the pioneer work of Warington.

I have recently isolated *Nitrosomonas europæa* Winogradsky[3,10] in pure culture from the soil of the farmyard manure plot on Broadbalk Field, Rothamsted. The organism has oval cells, 1·2–1·7 μ long and 1–1·2 μ broad. It is Gram-negative. I have not observed a motile form. On silica gel plates it forms brownish colonies, circular or star-shaped, about 100 μ across. It oxidizes ammonia to nitrite in a mineral medium, and will not grow on media containing peptone. In liquid cultures with excess of calcium carbonate, the cells adhere in masses to the carbonate at the bottom of the culture, and the supernatant fluid remains clear.

Details of the method used for isolation will be published later.

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Lysogenic Strains of Lactic Streptococci

During the propagation of starter cultures of lactic streptococci for cheese-making, the persistent appearance of phage in the bulk starter under certain conditions, after all known precautions had been taken against phage contamination, indicated that the presence of lysogenic strains was the probable explanation for the presence of bacteriophage.

Nichols and Hoyle[1] realized the importance of such strains, if detected, in the selection of lactic streptococci for cheese-making, but their attempts to demonstrate lysogenic strains among starter strains failed. They tried to show lysogenicity by growing pairs of strains together in broth after the method used successfully by Burnet[2] for *salmonella* strains and by adapting a method used by Fisk[3] for staphylococci strains on solid media. They found one strain, *C*30, which invariably produced innumerable plaques on agar, but they failed to find a suitable indicator strain on which the phage could be propagated so that *C*30 could be shown irrevocably to be lysogenic.

Hunter[4] reported that some strains of *Str. cremoris* exist in a symbiotic state with a phage, but these strains do not appear to be truly lysogenic because the organism can be freed from the phage 'carried' by plating and re-picking from solid media. This occurrence of phage resistant-carrier strains has been

confirmed[1] and shown to be important in the phage typing of lactic streptococci.

Williams Smith[5], working with phages for the staphylococci, noted that some batches of media were strongly inhibitory to phage action but, after the addition of $M/100$ calcium chloride to agar medium, a striking improvement in plaque formation occurred. If the phage contamination of bulk starter, referred to above, were due to undetectable lysogenic strains, then their presence might be shown by again applying the methods successfully used for other groups of bacteria, after adding calcium chloride, to the media.

Hitherto all attempts to demonstrate lysogenic strains have failed, but a technique has now been developed by which lysogenic strains have been successfully isolated from lactic streptococci.

The following is a typical example of the conditions under which phage, occurring in starter, was thought to arise from lysogenic strains; bulk starter was prepared daily by inoculation of the same can of milk with four strains of lactic streptococci (*HP* 950/5, M_2S_1, and *D*47/7). These strains had been grown separately until this sub-culture. After incubation, phage, which lysed one of the component strains *HP*, was frequently detected in the bulk starter by the activity test. Each of the four strains was smeared on to agar plates containing $M/100$ calcium chloride and the remaining strains 'spotted' on to each basal strain, after Fisk's method[3]. After the addition of calcium chloride, it was apparent that *HP* was an indicator strain lysed by the remaining three strains, which were lysogenic or phage-carrying. 950/5, M_2S_1 and *D*47/7 appeared to be true lysogenic strains, because after replating and picking colonies, sub-cultures when spotted on *HP* continued to lyse it.

Phages have been purified from these lysogenic lactic streptococci, and the phenomenon may be common among starter strains. In fact, several commercial lactic acid cultures were found to form plaques spontaneously if smeared on agar. In effect, this means that an additional precaution must be taken in their selection for cheese-making. Obviously, strains which are lysed by phages carried by lysogenic strains must be avoided when several separate strains are to be mixed daily to form the starter, or when the strains are to be used in a daily rotation.

BRUNO REITER

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Pregnancy Test using a European Male Toad

THE bulk of published work[1] on the use of male batrachians as pregnancy test animals has come from the Americas. Early last year, Galli Mainini[2] suggested that the test which he initiated using an Argentinian species *Bufo arenarum* Hensel[3] could probably be carried out equally well using an indigenous species, namely, *Bufo bufo*. A small series of tests was run on *Bufo arenarum* Hensel. The results[4] obtained encouraged us to employ the common toad *Bufo bufo*.

The method previously described[5] has been modified to allow for the small size of the animal—30 gm. approximately. The volume of urine injected was reduced to 5 ml. Prompt positive results were obtained within one hour, but the mortality among the toads injected was about 40 per cent. Recently, we have employed an elution method[6], and 2·5 ml. eluate are injected. Forty tests have been run with this method with a toad mortality of nil. We intend to run a further series, but reducing the quantity injected to 2·5 ml. untreated urine.

In seventy tests, including forty-eight cases of known pregnancy, we have obtained the expected number of positive results and there have been no false positives. Hinglais and Hinglais have reported favourably on the use of *Bufo bufo*[7] and *Rana esculenta*[8], while Bhaduri[9] has obtained comparable results with *Bufo melanostictus* in Calcutta. The importance of the male toad test for pregnancy is enhanced by its availability in different world regions using indigenous species.

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A Census of Mould Spores in the Atmosphere

THE aerial dissemination of certain types of fungus spores has been studied intensively by plant pathologists, and the literature on spore dispersal in general has been summarized from this point of view by Gregory[1]. Mould spores, however, not only cause infective disease in plants but may, as airborne allergens, also give rise to disease in man, and numerous studies have established their importance as a cause of asthma[2,3].

Two principal methods have been used to sample the atmospheric content of mould spores at or near ground-level, namely, the so-called gravity slide method and the culture plate method. Other methods, mostly involving the extraction of the spores from a measured volume of air[4,5], have been operated less widely or only on an experimental scale. The gravity slide method has been employed by Durham[6] over a wide area in the United States and also by Hyde and Williams in Great Britain[7]. This method can be operated continuously, but it has the disadvantage that the spores of relatively few fungi can be identified even generically. The culture plate method only allows of sampling for short periods (10–15 min. or so) at a time, but the mycelial colonies which develop after a few days incubation enable a greater variety of forms to be recognized. This method has been used extensively in America[3,8] and at a few centres in Europe[9,10]. Hitherto, no systematic observations by

this method appear to have been published in Great Britain.

We have carried out a preliminary survey of atmospheric moulds by the plate method during the twelve months December 1947–December 1948. A 9-cm. Petri dish containing Sabouraud's agar has been exposed for ten minutes at the same hour each morning of six days every week on the roof of Llandough Hospital, near Cardiff. The resulting colonies have been counted five days after exposure, kept under observation for a further five days, and so far as possible determined generically.

During the twelve months, 2,988 colonies in all have been counted, made up as follows: *Cladosporium*, 1,542; *Penicillium*, 380; *Pullularia*, 108; *Phoma*, 82; *Botrytis*, 69; *Aspergillus*, 34; *Alternaria*, 21; *Oospora*, 20; *Mucor*, 12; *Monilia*, 11; *Stemphylium*, 7; *Cephalosporium*, 7; *Rhizopus*, 4; *Trichothecium*, 2; *Nigrospora*, 1; *Papularia*, 1; *Verticillium*, 1; *sterilia* (white), 440; *sterilia* (red and white), 167; unidentified, 79. While the total number of colonies fluctuated widely week by week (and still more day by day), there was a marked maximum around mid-July and an equally marked minimum around mid-January. Among individual types *Cladosporium* was highest in summer, *Penicillium* in spring and autumn, *Pullularia* in May, *Phoma* in April and *Botrytis* in autumn. The work is being continued and a fuller account will be published elsewhere.

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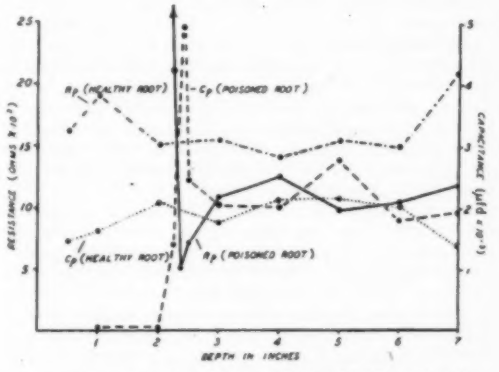
Diagnosis of Death in Roots

We have been interested in devising a simple method for determining the depth to which roots or underground stems of perennial weeds have been killed following the application of a poison to their tops, and have obtained useful results by means of a simple electrical method.

The equipment consists of a probe and a portable A.C. bridge. The probe, designed for robustness, consists of two metallic tips, for example, nickel-plated needle tips at $\frac{1}{8}$-in. separation, projecting $\frac{1}{2}$ in. from a glass tube in which their bases are held by means of a beeswax–resin mixture. The bridge is supplied from a 1,000 c.p.s. hummer with filter, and measures equivalent parallel resistance and capacitance (R_p and C_p). The probe is inserted into the root with the plane of the needles passing through the geometric axis of the root, and the bridge is then balanced.

On ascending from a lower, healthy portion of a root poisoned at its top, R_p decreases to a minimum and then increases. The decrease is attributable to the tissues becoming progressively more injured by poison[1] as the probe is moved upwards. The subsequent increase in resistance is attributable to the dead tissues having become desiccated. The lowest point of dead tissues is usually within one quarter of an inch of the locality at which the resistance is minimal. Thus in the accompanying diagram, R_p is minimal at a depth of $2\frac{3}{4}$ in. in the poisoned root. This root was dry and shrunken at a depth of $2\frac{1}{4}$ in. but exuded latex at a depth of $2\frac{3}{16}$ in. on being wounded[2]. Similar minima for resistance have been encountered in other roots where visual evidence of death is not so clearly marked. A particular convenience of the electrical method for diagnosing the lowest point of dead tissue is that it does not require destruction of a plant or its tissues. The diagram also illustrates the degree of variation found in a normal healthy root.



Graph showing variation of R_p and C_p in a healthy root and a poisoned root of skeleton weed (*Chondrilla juncea* L.). The lowest point of dead tissues in the poisoned root is close to the point at which R_p is minimal ($2\frac{3}{4}$ in. deep)

The values obtained for C_p do not give a true indication of the phase angle of the tissues, because they include the effect of a comparatively constant capacitive film around the probe tips. In fact, this series capacitance due to the film, together with the variations in resistance of the tissues between the probe tips, accounts for almost all of the variations recorded for C_p. Although the readings for C_p do not provide any additional information, they do serve as a useful cross-check on the location of the point of minimal resistance, the maximal value of C_p always corresponding with the minimal value of R_p.

We propose to publish further details elsewhere.

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Helical Fibrillar Arrangements in Jute

THE results described by Chakrabarti and Nodder in their communication entitled "Some Effects of the Helical Fibrillar Structure of Vegetable Fibres"[1] appear to be based on incorrect fibrillar arrangements. The following comments on the observed effects are, therefore, offered in an endeavour to clarify the issues involved.

The difference between the mean breaking twists, as reported, namely, 4·14–4·05, is about 2·0 per cent, which has no doubt statistical significance, but in view of the possible large error of measurements cannot be accepted as real. Assuming that the twist measurements have been made within an accuracy of 0·1 turns per inch, the error of measurement will then be about 5·0 per cent. Also, the figures for bundle diameters cannot be taken as really different, because in this case the difference between the two figures 1·78 and 1·76 is only about 1 per cent, which is again much less than the possible error of measurements. Increase in the number of observations reduces only the error of sampling; whereas the error of measurements, being dependent upon the instrument used, cannot be reduced by such means.

Calculating the standard error of the difference of the means for the breaking loads, it will be seen that the difference is significant only with sample *A*. Similar calculations indicate that the difference in the torsional rigidities is not significant in either of the samples *C* and *D*. It appears, therefore, that the differences in the mechanical properties are too small to be of any consequence.

An interpretation of this inappreciable difference can be given on the basis of the observed fibrillar arrangements for jute. X-ray and polarizing microscopic observations tend to confirm the previous results from microscopic study due to Hock[2], according to which the fibrillar arrangements in jute consist of a highly orientated structure of the secondary wall enveloped in a sheath of flat *Z*-twisted fibrillar wrapping of the primary wall. In flax, the *S*-twisted secondary wall is enveloped inside the *Z*-twisted primary wall. Since the drying twist reflects only the direction of the restoring torque tending to bring the fibrils back to their original spiral configurations, it should be clockwise for flax and counter-clockwise for jute. Laboratory observations and also Hock's report confirm this order of the drying twist in the case of jute. With flax, the influence of the primary wall in determining the drying twist is counterbalanced by the overwhelming influence of the secondary wall; with jute, however, on account of the absence of the spiral arrangement in the secondary wall, the drying twist is decided by the fibrillar arrangement in the primary wall. It does not follow, however, as a necessary consequence that the mechanical properties of jute will be decided by such a thin layer of primary wall, which constitutes only a small fraction of the total cellulose content of the fibres. Inasmuch as the properties, breaking twist, twisted diameter, and breaking load after twisting, are the properties of the bulk of the materials, they should be naturally dependent on the structure of the secondary wall, which in the case of jute is composed of highly oriented cellulose chains. The order of twist, clockwise or counter-clockwise, will, however, have very little, if any, effect on any of these properties. The figures given by Chakrabarti and Nodder indicate, if anything, that the influence of the sense of twist on the mechanical properties is negligible.

The conclusions derived by the authors do not, therefore, seem valid for the following reasons: (1) the observed differences lie within the errors of measurements; (2) the interpretations of the data have been given on the basis of wrong fibrillar arrangements; and (3) the explanation given for the contrary relation between the breaking load and the direction of twist is highly improbable.

Another mistake committed by the authors is in regard to the interpretations of the results on torsional rigidity. According to the fundamental definition, rigidity is an intrinsic property of a material depending only upon the shape and the internal structure. It is difficult to understand, therefore, why rigidity values should be different in the two cases of *Z*- and *S*-twists. In fact, the rigidity figures given by the authors do not show any such differences, and that is what one would expect.

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Competitive Inhibition of Sulphate Reduction by Selenate

Butlin, Adams and Thomas[1] have described methods for the isolation and cultivation of pure strains of *Desulphovibrio desulphuricans*. In order to grow large numbers of cells for manometric work, it is preferable to use a richer medium than any of those described, and one based on peptone and glucose has been found capable of supporting massive growth of certain strains (up to about 0·8 mgm. dried cells/ml.) in about seventy-two hours, growth being visible in less than twenty hours. Its composition is: glucose 10·0 gm.; $MgSO_4.7H_2O$, 1·5 gm.; Na_2SO_4, 1·5 gm.; 'Difco' peptone, 20 gm., *or* 'Difco' peptone, 5 gm., and yeast extract, 4 gm.; tap water, 1,000 ml.; *p*H 6·3. No addition of iron is necessary, and no ferrous sulphide is precipitated during growth.

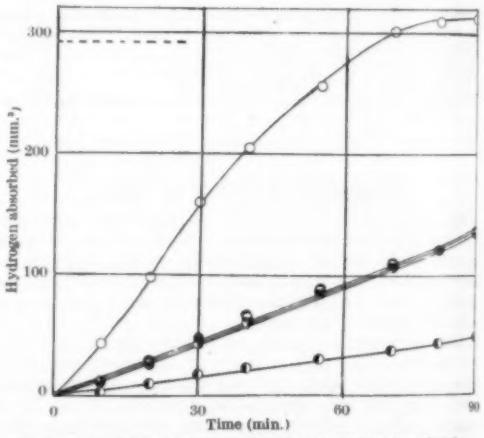

Fig. 1. Competitive antagonism of sulphate reduction by selenate.
○, Na_2SO_4, $1·3 \times 10^{-3}$ *M*.
◒, Na_2SO_4, 2×10^{-1} *M*; Na_2SeO_4, 4×10^{-2} *M*.
◒, Na_2SO_4, 2×10^{-2} *M*; Na_2SeO_4, 4×10^{-4} *M*.
◑, Na_2SO_4, 2×10^{-3} *M*; Na_2SeO_4, 4×10^{-5} *M*.
●, no added substrate.
Broken line, theoretical uptake of hydrogen with $1·3 \times 10^{-3}$ *M* Na_2SO_4

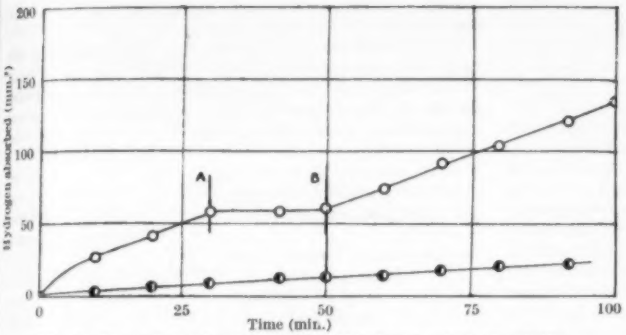

Fig. 2. Reversal of selenate inhibition of hydrogen uptake by sulphite.
○, Na_2SO_4, 10^{-3} *M* added at start.
●, no added substrate.
A, sodium selenate added; *B*, sodium sulphite added

Cells can be grown, washed with 0·8 per cent sodium chloride, and the suspension used for manometric studies of their hydrogen uptake. 1 ml. of a suspension containing about 2 mgm. of dried cells/ml. is used in the Warburg manometer at 37° C. with 1 ml. of 0·5 per cent potassium dihydrogen phosphate buffer at *p*H 6·3 and 0·5 ml. of substrate. 15 per cent sodium hydroxide is used in the centre cup to absorb hydrogen sulphide and any carbon dioxide that may be evolved. It is necessary to incubate the cell suspension in a stream of hydrogen for one or two hours before use, to remove traces of substrate carried through the washing procedure. Even so, there is normally a small 'blank' hydrogen uptake in the absence of added substrate which cannot conveniently be eliminated as it persists even after a further 24 hours pre-incubation.

Using one of the laboratory strains of *D. desulphuricans*, the observation of Stephenson and Stickland[2] that sulphate (Na_2SO_4) is reduced with an uptake of four molecules of hydrogen per ion of sulphate has been confirmed; the optimal *p*H is 6·3. Sulphite ($Na_2SO_3.7H_2O$) is reduced by three molecules of hydrogen at an optimal *p*H of about 6·7, and thiosulphate ($Na_2S_2O_3.5H_2O$) is completely reduced using four molecules of hydrogen at an optimal *p*H of about 7·0. These findings are consistent with the equations:

$$SO_4'' + 4H_2 = S'' + 4H_2O$$
$$SO_3'' + 3H_2 = S'' + 3H_2O$$
$$S_2O_3'' + 4H_2 = 2SH' + 3H_2O.$$

Selenate (Na_2SeO_4) is not reduced and is a powerful inhibitor of sulphate reduction, though it does not prevent the 'blank' hydrogen uptake referred to above. This inhibition is competitive, since the rate of hydrogen uptake is constant and suboptimal over a 100-fold range of selenate concentration if the selenate : sulphate ratio is 0·02 (Fig. 1). If this ratio is increased to 0·1, inhibition is complete.

The inhibition of hydrogen uptake by selenate is overcome in a non-competitive manner by addition of sulphite (Fig. 2). The reduction of sulphite under these conditions is incomplete, however, in the sense that less than the theoretical number of hydrogen molecules per ion of sulphite are taken up. The rate of sulphite reduction is independent of the selenate concentration up to 10^{-2} *M* SeO_4''.

The selenate ion can, therefore, interfere specifically with the reduction of the sulphate ion owing probably to its structural resemblance to sulphate. In this connexion it is remarkable among metabolite antagonists in having an inhibitor–metabolite ratio considerably less than 1·0. Hurd-Karrer[3,4] has shown selenate to have a similar intense activity in antagonizing the absorption of sulphate by wheat plants.

Many workers (see Starkey[5]) consider that the reduction of sulphate by hydrogen at a metallic iron surface is a key reaction in the anaerobic corrosion of iron pipes by sulphate-reducing bacteria. It is possible that specific inhibition of this reaction by sulphate analogues will be of value in the prevention of such corrosion.

The work is being continued and will be reported in detail elsewhere.

This note is published by permission of the Director of the Chemical Research Laboratory, Teddington.

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May 16.

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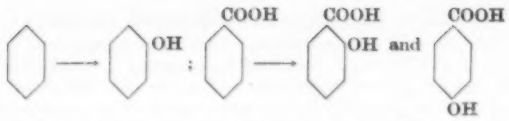
Chemical Measurement of Ionizing Radiations

RADIATION 'dose' is usually defined and measured in terms of the ionization produced in air. However, for biological dosage purposes it would be theoretically preferable to measure effects produced in media similar in composition to living tissue, and there are considerable experimental advantages in a direct measurement of the radiation energy dissipation in liquid or solid media[1,2]. Our experiments, with *X*-rays, gamma-rays and beta-rays, confirm that radiation absorption in aqueous solutions can be accurately measured by purely chemical means.

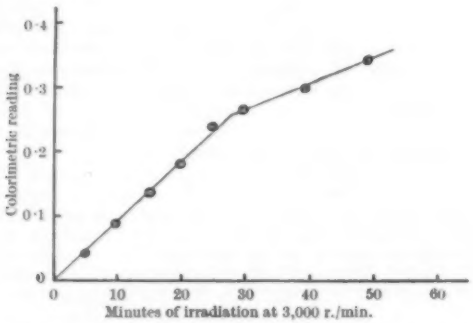
Ionizing radiations produce, in aqueous solutions, chemical changes which can be interpreted as due to the action of hydrogen and hydroxyl radicals[3]. In the presence of oxygen, the hydrogen atoms can form HO_2 radicals, which process can contribute to an increased chemical yield.

Many substances can act as 'acceptors' for the radicals, and the resulting products may serve as a measure of the radiation dose. The actual choice is governed by experimental requirements. The 'radiation indicator' must react readily with the radicals, and for X-ray dosage its effective atomic number must be about the same as for water. It is a great advantage to be able to work in the presence of air, and the 'indicator' must be stable under these conditions. The irradiation products must also be stable and capable of being estimated in very high dilution. The yield should be independent of the concentration of the acceptor.

We have found that these requirements are adequately met by benzene and sodium benzoate, which are hydroxylated with the formation (among other substances) of phenolic products[4].



Phenols are readily estimated colorimetrically using Folin's reagent, which we find can be added directly to the irradiated solution. Yields are found to be not critically dependent on *p*H, concentration or temperature. A solution of salicylic acid is used as a purely empirical chemical standard, We normally work in the presence of air, which gives a yield directly proportional to the dose up to about 60,000 roentgens (depending on the amount of oxygen present in solution), after which the reaction proceeds with decreased yield in the virtual absence of oxygen (see graph).



The roentgen provides a radiation standard for which National Physical Laboratory calibrations are available. 1 c.c. quantities of 0·5 per cent sodium benzoate were irradiated with X-rays, the dose being measured with an ionization chamber[5], making corrections for divergence, absorption and scatter of the incident beam. An automatic X-ray regulator[6] enabled an accurately known dose to be given. Radium C gamma-rays were also used.

Relative yields per energy unit[7] at different effective wave-lengths were as follows :

Chemical yields : sodium benzoate 0·5 per cent

Wave-length in A.	0·015	0·12	0·18	0·23	0·32	0·41	0·46
Relative yield	0·96	1·00	1·02	0·97	1·00	1·02	0·99

Within the limits of experimental error, this shows that the chemical effect is, in fact, a measure of the quantity of radiation energy absorbed.

Absolute yields in the presence of air were as follows :

Sodium benzoate 0·5 per cent: 1 energy unit is equivalent to $6·04 \pm 0·15 \times 10^{-16}$ gm./c.c. salicylic acid.
Benzene (saturated aqueous solution): 1 energy unit is equivalent to $5·85 \pm 0·20 \times 10^{-16}$ gm./c.c. salicylic acid.
Assuming the mean energy required to form an ion-pair in air as 32·5 eV., 1 energy unit = 93·1 ergs/gm.

The following are possible applications of chemical radiation dosimetry: (*a*) determination of total energy absorption in irregular volumes non-uniformly irradiated; (*b*) measurement of very high dose-rates; (*c*) measurement of doses with very high energy quanta, for which the roentgen begins to lose its significance; (*d*) measurements with very broad X-ray spectra; (*e*) absolute determination of radioactive substances, especially beta-ray emitters, which can be incorporated in the radiation indicator solution.

Such experiments have been carried out, and details will be published separately.

We should like to express our gratitude for the help we received from Dr. F. T. Farmer and Dr. J. Weiss, and for the co-operation of various departments of the Royal Victoria Infirmary, where the experiments were carried out.

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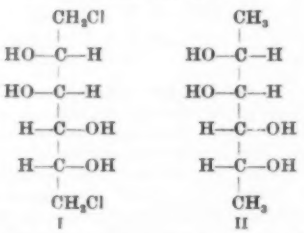
Dianhydrohexitols Derived from Mannitol

In an exhaustive study of the action of hydrochloric acid on mannitol, Montgomery and Wiggins[1] isolated no fewer than four dianhydrohexitols from this reaction. These compounds were : (*a*) 1 : 4-3 : 6-dianhydromannitol (*iso*mannide) ; (*b*) 1 : 5-3 : 6-dianhydromannitol (neomannide) ; (*c*) dianhydrohexitol (*A*), m.p. 118°, $[\alpha]_D - 34°$; and dianhydrohexitol (*B*), isolated only as its dimethanesulphonate, m.p. 113–114°. The constitution of the latter two compounds has not yet been determined.

The action of sodium methoxide on 1 : 6-dichloro-1 : 6-dideoxymannitol (I) has now been investigated and another dianhydrohexitol isolated. The interesting feature of this new compound is that it is the enantiomorph of the dianhydride (*A*) obtained from the action of hydrochloric acid on mannitol. It had m.p. 118° and showed $[\alpha]_D + 34°$. It would appear that such a transformation could only be effected through the occurrence of Walden inversion at some point in the mannitol molecule. Therefore it is of great interest to determine the constitution of the dianhydride (*A*), and work on this project is being undertaken in these Laboratories.



Furthermore, the reaction of 1 : 6-dichloro 1 : 6-dideoxymannitol with sodium amalgam has been found to lead to yet another dianhydrohexitol. This substance had m.p. 118° and at first sight might appear to be identical with the dianhydride (*A*) ; its specific rotation was, however, markedly different ($[\alpha]_D + 94°$). This dianhydride is identical with the β-mannide obtained by Siwoloboff in 1886 [2]. It has now been characterized as the dimethanesulphonate, m.p. 121°, the di-toluene-*p*-sulphonate, m.p. 115·5°,

and the dibenzoate, m.p. 97·5°, and active work on the constitution of this anhydride is also in progress. The normal action of sodium amalgam on 1 : 6-dichloro 1 : 6-dideoxymannitol would be the exchange of the two chlorine for hydrogen atoms in (I), and this has, indeed, taken place, since the isolation from the reaction mixture of crystalline 1 : 6-dideoxymannitol (II), m.p. 147–148°, has also been accomplished.

I am grateful to the Colonial Products Research Council for financial support during this investigation.

L. F. Wiggins

A. E. Hills Laboratories,
University, Birmingham 15.
April 28.

[1] Montgomery, R., and Wiggins, L. F., *J. Chem. Soc.*, 2204 (1948).
[2] Siwoloboff, A., *Annalen*, **233**, 372 (1886).

Increase of Oxygen Overpotential at a Platinum Anode by Reducing Agents

During a study of electrolytic oxidation processes, the surprising observation has been made that the presence of low concentrations of certain reducing agents, which normally function as depolarizers, will bring about very substantial *increases* in the potential at which oxygen is evolved at a platinum anode. The effect was first noted with dilute solutions of sodium thiosulphate in phosphate buffer electrolysed at high current densities, but it has since been found to occur to varying extents with a large number of oxidizable substances containing sulphur and/or nitrogen. The phenomenon has been studied by polarizing a clean platinum wire anode in an inert electrolyte until the potential became substantially steady; a quantity of the oxidizable substance was then added and the anode potential observed over a further period of electrolysis. In general, where the added substance was active in giving the effect, an almost immediate rise of potential occurred which reached a maximum value within a few minutes. Below are shown the elevations of anode potential observed after two minutes with a variety of addition agents, each at a concentration of 0·01 *M*, in the electrolysis of a phosphate bufier (0·2 *M* KH_2PO_4 + 0·2 *M* Na_2HPO_4, *p*H 6·8) at 20° C. with an anodic current density of 0·15 amp./sq. cm.

Substance added	Rise of potential
Thiourea	0·63 volt
Ammonium thiocyanate	0·59
Sodium tetrathionate	0·45
Sodium sulphide	0·44
Urea	0·41
Sodium thiosulphate	0·37
Thioglycollic acid	0·34
Hydroxylamine sulphate	0·22
Sodium azide	0·20
Biuret	0·20
Sodium sulphite	0·18
Sodium nitrite	0·17
Metol	0·16

No comparable effects were observed with other oxidizable substances not containing sulphur or nitrogen.

The phenomenon now reported is not specific to any one electrolyte, but has been observed in acid and alkaline electrolytes of different types, and the magnitude of the effect seems to increase with increasing acidity. Thus, under the same conditions as before, thiourea produced an elevation of 0·84 volt in *N* sulphuric acid, 0·63 volt in phosphate buffer, and 0·43 volt in *N* potassium hydroxide. A limited investigation (using sodium thiosulphate and tetrathionate) of the influence of concentration of the oxidizable substance showed that, even at a concentration of 0·0001 *M*, a small but appreciable rise of potential was produced; this increased rapidly with rise of concentration to a very flat maximum between 0·005 and 0·01 *M*, and thereafter decreased. Provided the working current-density was above the limiting value for diffusion of the added substance to the anode, so that oxygen was always evolved, variation of current density appeared to have little influence on the magnitude of the elevation, and substantially the same results were obtained over the range 0·05–0·3 amp./sq. cm.

The effect appears to be specific to platinum as anode material, since no elevation of potential has been observed with gold, palladium, graphite and nickel anodes, and the phenomenon thus appears to have some features in common with the influence of fluoride, the presence of which has long been known[1] to raise the oxygen overpotential at platinum, but which has little influence at other electrode materials[2]. The present effects, however, are much greater than those observed with fluoride under comparable conditions.

It might at first sight be thought that the substances which produce the potential elevations act by poisoning the electrode surface; but this does not appear to be so, since an anode at which the potential has been raised undergoes no permanent change, and on rinsing with water and inserting in fresh electrolyte gives its normal (low) potential. The effect appears to be bound up with the oxidation of the added substance, and in prolonged electrolyses the potential decreases as the addition agent is used up. Any suggestion as to the cause of the phenomenon must at present be entirely speculative, but it appears possible that the effect may be brought about by the added substance removing some essential intermediate involved in the evolution of oxygen at a platinum anode, and so retarding the rate of the electrode reaction.

A. Hickling
W. H. Wilson
Department of Inorganic and Physical Chemistry,
University of Liverpool.
May 5.

[1] Müller, *Z. Elektrochem.*, **10**, 776 (1904). Müller and Scheller, *Z. anorg. Chem.*, **48**, 112 (1906).
[2] Hickling and Hill (unpublished work).

Chromatography on Alumina-impregnated Filter Paper

Since the technique of paper partition chromatography is generally inapplicable to fat-soluble substances, we have investigated the use of alumina-impregnated filter paper for this purpose. We have found that such paper run in simple organic solvents forms, in effect, an adsorption chromatogram on a micro scale, and combines the advantages of alumina chromatography with the elegance of paper chromatography.

Flood[1] has shown that filter paper when impregnated with alumina exhibits selective adsorption of inorganic ions. He confined his attention to the chromatography of inorganic cations by a method which seems to depend on ion exchange with cations present in the alumina. Hopf[2] further developed the method and has employed papers containing other adsorbents; for example, blotting paper containing fullers' earth, and starch paper. He also incorporated in the paper reagents forming coloured complexes

with the constituents of the solution to be analysed. He, too, confined his attention largely to inorganic cations, though he also investigated the behaviour of a few simple organic molecules. We wish to emphasize the possibilities of extending these methods to large water-insoluble organic molecules.

We have found that filter paper may most conveniently be impregnated with alumina by the following method. Strips of Whatman No. 54 filter paper, which combines great wet strength with a loose texture, are dipped first in an aqueous solution of aluminium sulphate (65 gm. per litre), allowed to drain, and then dipped in dilute ammonia (2*N*). The immersion in ammonia should not be hurried, as the precipitated aluminium hydroxide, by forming a gelatinous layer on the surface of the paper, hinders the diffusion of ammonia into the body of the paper. When a heavy impregnation with alumina is desired, the papers may be dipped in stronger aluminium sulphate solution and allowed to hang overnight in a damp atmosphere saturated with ammonia vapour. The strips are washed in running tap water for at least five hours and are then dried. The temperature at which the papers are dried, which cannot exceed 140° C. because of charring, appears to have only a slight effect on the activity of the alumina. Papers dried at 140° C. give only slightly smaller R_F values than those which have been dried at room temperature. Conditions of storage seem to have a greater effect, since definite changes occur on ageing; it is of interest that Flood also noticed this effect and gives instructions for ageing the papers. Slight gradations of R_F values are obtained between papers stored over different concentrations of sulphuric acid; the stronger the acid the more strongly adsorbing are the papers. Very strongly adsorbing papers may be obtained by storing over phosphorus pentoxide. The activity of the paper, however, is not easily controllable, and it is more convenient to run an indicator spot parallel to the unknown on the same strip of paper. This indicator may be either a known sample of the substance to be detected or a dye such as one of the Brockmann alumina standardization dyes. A calibration curve may be constructed relating the R_F of a suitable Brockmann dye with that of the substance to be detected.

We have applied this technique to the separation of vitamin A alcohol, esters of vitamin A, retinene and other Carr–Price chromogens[3]. We are now extending this work to carotenoids, steroids and certain azo dyes.

S. P. Datta
B. G. Overell
M. Stack-Dunne

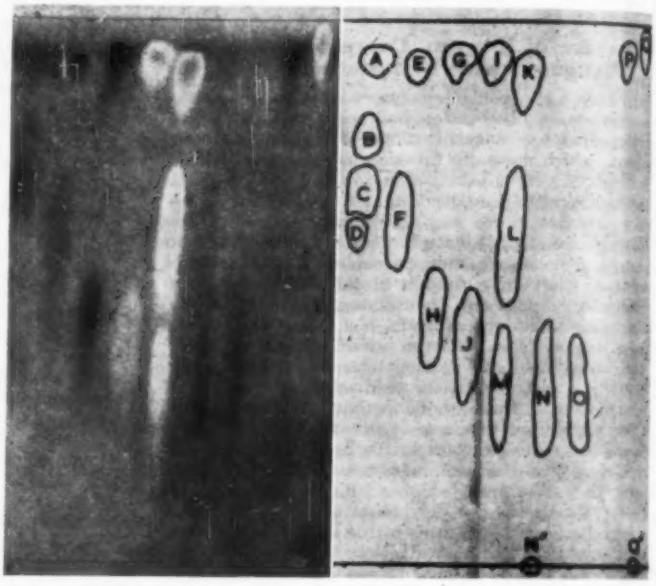
Biochemistry Department,
University College,
London. May 30.

[1] Flood, H., *Z. anal. Chem.*, **120**, 327 (1940).
[2] Hopf, P. P., *J. Chem. Soc.*, 785 (1946).
[3] Datta, S. P., and Overell, B. G., *Biochem. J.*, **44**, xliii (1949).

Paper Partition Chromatography of Phenolic Substances

The technique of paper chromatography devised by Consden *et al.*[1] for the qualitative analysis of amino-acids has since found wider spheres of application[2]. Bate-Smith[3] described its application to anthocyanins, flavones and other polyphenolic substances.

We have developed a modification of the technique, designed to separate phenolic acids from their parent phenols and from each other, in quantities of the order of 5 μgm. This method has been found of considerable value in research into the pathways of bacterial oxidation of aromatic compounds, since by its use it was first shown[4] that catechol was an intermediate formed during benzoic acid breakdown.



One-dimensional chromatogram of some phenolic substances. The letters on the key correspond to those in the table. *N'*, *Q'* indicate some decomposition at point of deposition

Our modification involved the use of No. 4 Whatman filter paper developed one-dimensionally by the method of capillary ascent[4]. The mobile fluid found most satisfactory was the organic phase of a mixture of one part butanol, one part pyridine and two parts of a saturated solution of sodium chloride. A development time of 15 hours was suitable, giving a solvent run of 30 cm. at room temperature. The position of the spots was observed by spraying with a colouring agent, after drying in a rapid current of hot air until no smell of pyridine remained. Neither ferric chloride solution nor ammoniacal silver nitrate[3] was found to be as satisfactory as diazotized sulphanilic acid (Pauly reagent). This was made up in 50 per cent ethanol and, when most of the solvent had evaporated, was followed by fuming with ammonia. The colours given by the various compounds show up against a medium yellow background, and are listed in the accompanying table together with the R_F' values. R_F' values were measured to the leading edge instead of the 'centre of gravity' of the spot, as this gave more consistent results. Examination of the dried chromatogram by ultra-violet light

Substance	Colour with diazotized sulphanilic acid	R_F'	S.D.
A Phenol	Deep yellow	0·97	0·01
B *p*-Hydroxybenzoic acid	" "	0·85	0·02
C *m*-Hydroxybenzoic acid	" "	0·74	0·01
D Salicylic acid	Pale yellow	0·65	0·02
E Catechol	Reddish-brown	0·96	0·00
F Protocatechuic acid	" "	0·74	0·01
G Resorcinol	Brown	0·97	0·00
H *β*-Resorcylic acid	"	0·55	0·03
I Hydroquinone	Colourless	0·96	0·01
J Gentisic acid	"	0·51	0·01
K Pyrogallol	"	0·94	0·01
L Pyrogallol carboxylic acid	"	0·71	0·04
M Gallic acid	"	0·43	0·03
N Hydroxyquinol	Brown	0·48	0·04
O Hydroxyquinol carboxylic acid	"	0·45	0·01
P Phloroglucinol	Orange	0·96	0·02
Q Tannic acid	Colourless	0·99	0·01
Guiacol	Orange		
Thymol	Yellowish-brown	0·95	
α-Naphthol	Brownish-red		
β-Naphthol	Orange		

before colouring it will show if gentisic acid is present, as this substance gives a vivid blue fluorescence.

The chromatogram shows the position of the main compounds tested, but for photographic purposes it had to be somewhat overloaded—this accounts for the diffuse nature of some of the spots. All phenols (including naphthols and phenolic aldehydes) have similar high R_F' values, but the method will, for example, separate the three mono-hydroxy benzoic acids from one another and from phenols. Anomalous R_F' values appear to characterize hydroxyquinol and tannic acid; in both cases some decomposition at the point of deposition seems to occur.

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W. H. Parr
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Department of Animal Health,
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May 2.

[1] Consden, R., Gordon, A. H., and Martin, A. J. P., *Biochem. J.*, **38**, 224 (1944).
[2] Consden, R., *Nature*, **162**, 359 (1948).
[3] Bate-Smith, E. C., *Biochem. J.*, **43**, xlix (1948).
[4] Evans, R. A., Parr, W. H., and Evans, W. C., *Biochem. J.*, **44**, viii (1949).
[5] Williams, R. J., and Kirby, H., *Science*, **107**, 481 (1948).

Entomology as a Career

Every generation produces a number of young naturalists, some of whom seek a career in which they can follow their interests. Of these a proportion have in the past turned to entomology, and it is to be hoped that they will continue to do so in the future. The proceedings of a recent conference held in London, the Second International Congress of Plant Protection, and a remark in the presidential address to the Society of Chemical Industry[1] tend to support the view—much fostered by interested parties at the present time—that entomology in its applied aspects is no longer the province of the biologist, but is rapidly becoming, if it has not already become, that of the chemist and physicist. Sir David Rivett, in the address referred to, said, "When for example one approaches a problem of pest insect control, may it not well be that a physicist, aided by a mathematician and guided by a chemist, will prove of more value than any other worker?"

If this point of view becomes widely accepted, as it is in danger of being, then doubtless it will tend to divert from the profession those who delight in handling and studying living things, thus leaving the field to followers of the 'dead' sciences.

Nothing could be further from the truth than that knowledge leading to the better control of injurious insects is to be sought in the main from chemists. While they are necessary auxiliaries to entomologists in this field and are to be congratulated on recent striking contributions in the field of insecticides, it is from biologists, more especially ecologists, that future additions to needed knowledge concerning insect pests must be sought, knowledge on which the chemist's contribution must depend and without which, in many instances, it can be of no account.

Frequently a study of an insect pest in relation to its environment has yielded information enabling simple and inexpensive measures of control to be applied, such as may be brought about by a modification of farming practice. Such measures, when available, are always preferable to chemical control ones, which are never cheap and sometimes accomplish harmful, unforeseen results.

It is probable that at the moment more openings exist in a varied field for trained, young biologists than has ever been the case previously. Those who are drawn to the study of insects need have no fear that in becoming entomologists they may be entering a dying profession, for the study of living insects will always remain the basic approach to problems of insect control. Entomology will thus, in the future, as in the past, continue to offer an interesting career to followers of the 'live' sciences.

J. W. Evans
Ministry of Agriculture and Fisheries,
Infestation Control Division,
London, W.C.

[1] *Chemistry and Industry*, **30**, 527 (1949).

The Dry Crossing of the Nile

In *Nature* of November 6, 1937, p. 811, and September 24, 1938, p. 576, letters were published on the 'Dry Crossing of the Nile'. This crossing was a mass of floating vegetation where the river is 80 yards across, and the 'bridge' was about 250 yards from its upstream to its downstream edge. It was sufficiently strong for elephants to cross. A photograph taken by Dr. Alexander Cruickshank, from whom these particulars were obtained, was reproduced. My son, Colonel F. O. Cave, has obtained further particulars from Mr. Siricio Iro, a member of the Sudan Legislative Assembly, whose home is in the neighbourhood of the crossing, from which it appears that grass, trees and vegetation, brought down by floods, are held up by a large rock in mid-stream which acts as a foundation for the bridge, which apparently lasts until the vegetation over the rock has rotted. The last two bridges remained intact for eight and ten years respectively, the last one being washed away in 1946. Further local information indicates that the bridge started to reform in July 1948 but was washed away again by very heavy floods in the following October. A Sudan official who walked along the banks of the Nile from Nimule to Juba in March 1949 saw no sign of a dry crossing.

C. J. P. Cave
Stoner Hill,
Petersfield.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 17

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Dr. E. J. F. James: "The Education of the Brilliant Child" (Presidential Address).*

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the SOCIETY OF CHEMICAL INDUSTRY, at the County Technical College, Essex Road, Dartford), at 7.30 p.m.—Dr. H. Barron: "Plastics and Corrosion".

CHEMICAL SOCIETY, OXFORD BRANCH (in the Physical Chemistry Laboratory, Oxford), at 8.15 p.m.—Mr. H. M. Powell: "Compounds of the Inert Gases" (Alembic Club Lecture).

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 8.15 p.m.—Mr. Wilfred Thesiger: "Travels in Central Oman".

Tuesday, October 18

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. D. McKie: "Newton and Alchemy".*

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, Kensington Gore, London, S.W.7), at 2.30 p.m.—Third Annual General Meeting.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (joint meeting with the AGRICULTURE GROUP of the SOCIETY OF CHEMICAL INDUSTRY and the FERTILISER SOCIETY, in the Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Papers on "Fertiliser Analysis, with special reference to Available Phosphoric Acid".

EAST MALLING RESEARCH STATION (at Bradbourne House, Larkfield, near Maidstone), at 4 p.m.—Mr. B. S. Furneaux: "The Soil and the Fruit Tree" (Amos Memorial Lecture).*

INSTITUTE OF PETROLEUM, NORTHERN BRANCH (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Dr. Broom: "Turbine Lubrication".

INSTITUTION OF ELECTRONICS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 6.30 p.m.—Mr. J. Blears: "Mass Spectrometry".

MANCHESTER GEOGRAPHICAL SOCIETY (at the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Prof. W. J. Pugh: "The Exploration of the Oceans".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. E. G. Broadbent: "Some Considerations of the Flutter Problems of High Speed Aircraft".

Wednesday, October 19

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. W. E. Le Gros Clark, F.R.S.: "The Geological History of the Hominoidea" (Fifth William Smith Lecture).

ROYAL MICROSCOPICAL SOCIETY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Sir Paul Fildes, F.R.S.: "Growth and Reproduction of Bacteria".* (Further Lectures on October 20 and 21.)

INSTITUTION OF ELECTRICAL ENGINEERS, NORTH-WESTERN RADIO GROUP (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Discussion on "Wave Guides" (to be opened by Mr. E. Colin Cherry).

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. J. G. A. Griffiths: "Rocket and Chemistry", followed by Film, "Rocket Flight".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the NORTHERN IRELAND SECTION, in the Agricultural Chemistry Department, Queen's University, Elmwood Avenue, Belfast), at 7.30 p.m.—Prof. R. G. Baskett: "Agricultural Chemistry in Northern Ireland".

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 8.15 p.m.—Dr. J. Waechter: "Recent Fieldwork in the Near and Middle East, 2, The Old Stone Age in Asia Minor in the Light of Recent Exploration".* (Further Lectures on October 26, November 2, 9, 16, 23, 30, December 7 and 14.)

Thursday, October 20

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, BIOLOGICAL METHODS GROUP (joint meeting with the SOCIETY FOR ENDOCRINOLOGY, at the Medical Society of London, Chandos Street, Cavendish Square, London, W.1), at 2.15 p.m.—Symposium on "Hormone Assay".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. P. H. Kitto: "The Use of the Wet Kata Thermometer on the Witwatersrand"; Messrs. H. L. Talbot and H. N. Hepker: "Investigations on the Production of Electrolytic Cobalt from a Copper-Cobalt Flotation Concentrate".

CHEMICAL SOCIETY, HULL BRANCH (joint meeting with the UNIVERSITY COLLEGE SCIENTIFIC SOCIETY, in the Science Lecture Theatre, University College, Hull), at 6 p.m.—Prof. A. R. Todd, F.R.S.: "The Mechanism of Drug Action".

CHEMICAL SOCIETY, NOTTINGHAM BRANCH (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Lecture Theatre, the University, Nottingham), at 6.30 p.m.—Dr. E. J. Bowen, F.R.S.: "The Scattering of Light by Solutions".

CHEMICAL SOCIETY (in the Main Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.15 p.m.—Prof. E. R. H. Jones: "Acetylene and Acetylenic Compounds in Organic Synthesis" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. H. E. Shortt: "Tropical Medicine as a Career" (Presidential Address).

Friday, October 21

INSTITUTE OF PHYSICS, INDUSTRIAL SPECTROSCOPY GROUP (at 47 Belgrave Square, London, S.W.1), at 4 p.m.—Annual General Meeting; Dr. F. G. Tryhorn: "Physical Methods in the Forensic Laboratory".

INSTITUTE OF PHYSICS, MANCHESTER AND DISTRICT BRANCH (joint meeting with the LOW TEMPERATURE GROUP of the PHYSICAL SOCIETY, in the New Physics Theatre, the University, Manchester), at 4.30 p.m.—Prof. M. G. Evans, F.R.S.: "Some Factors influencing the Formation of Azeotropes"; Mr. E. Crewdson and Mr. P. E. F. Crewdson: "The Development of a Low Temperature Air Expansion Turbine"; at 7 p.m.—Reports by British Physicists on the Conference on "Very Low Temperatures" held at the Massachusetts Institute of Technology.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. Bernhard Katz: "Transmission of Excitation in Nerve and Muscle".* (Further Lectures on October 28, November 4, 11, 18 and 25.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. A. V. Judges: "Education and Social Dynamics" (Inaugural Lecture).*

TELEVISION SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Mr. J. T. Mould: The Fourth Fleming Memorial Lecture.

Saturday, October 22

BIOCHEMICAL SOCIETY (in the Biochemistry Department, King's College, Strand, London, W.C.2), at 2 p.m.—Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY, MIDLAND BRANCH (at the Institute of Education, The University, Derby Road, Nottingham), at 2.30 p.m.—Dr. M. M. Lewis: "The Relation between Communication and Group Behaviour in Modern Society".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Harustiati Subandrio: "Shadow-Plays of Java".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH OFFICERS (2) and RESEARCH ASSISTANTS (3) IN THE MINISTRY OF TOWN AND COUNTRY PLANNING—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 2768 (October 20).

CHEMISTS (Senior Experimental Officer and Experimental Officer grades) in the Chemical Inspectorate (Atomic Energy), and CHEMISTS (Experimental Officer grade) at the Atomic Energy Research Establishment, Harwell—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2774 (October 20).

ASSISTANT in the abstracting and information service in the Secretariat of the Inter-Departmental Insecticide Committee—The Secretary, Agricultural Research Council, 6a Dean's Yard, London, S.W.1 (October 22).

SENIOR LECTURER IN MECHANICAL ENGINEERING, a RESPONSIBLE LECTURER IN MECHANICAL ENGINEERING, and a LECTURER IN MECHANICAL ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (October 22).

CHIEF TECHNICAL OFFICER to the National Research Development Corporation—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.234/49AA (October 22).

PROJECT ENGINEERS (Principal Scientific Officer and Senior Scientific Officer grades) in London under the Ministry of Fuel and Power—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.533/49AA (October 25).

ASSISTANT BOROUGH ANALYST AND DEPUTY GAS EXAMINER—The Borough Analyst, Analyst's Laboratory, Civic Centre, Southampton, endorsed 'Assistant Borough Analyst' (October 28).

RESEARCH ASSISTANT on flow of liquids in porous materials, with particular reference to land drainage—The Secretary, School of Agriculture, Cambridge (October 31).

SUPERINTENDENT IN THE PRODUCTION DIVISION of Atomic Energy to take complete charge of a large factory at Springfields, Preston, engaged in the production of atomic energy material—The Staff Section, Ministry of Supply, Division of Atomic Energy (Production), Risley, near Warrington, Lancs.

LECTURER IN CHEMISTRY—The Registrar, Portsmouth Municipal College, Portsmouth.

LECTURER IN THE DEPARTMENT OF MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield.

RESEARCH CHEMIST, with good Honours degree and preferably some experience of research—The Director of Research, Research Association of British Flour-Millers, Cereals Research Station, Old London Road, St. Albans, Herts.

GRADUATES IN PHYSICS or CHEMISTRY, to undertake research in connexion with the Pottery Industry—The Director of Research, British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

GRADUATE IN SCIENCE, for work on scientific information services—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.